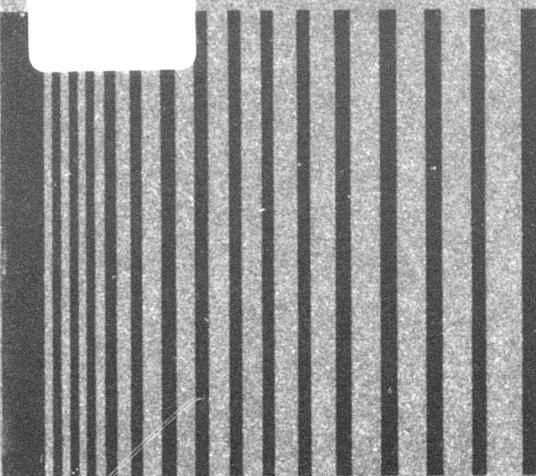


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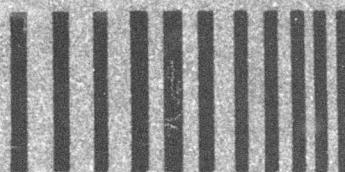
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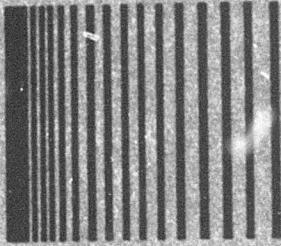


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# THE SHOCK AND VIBRATION DIGEST

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# SVIC NOTES

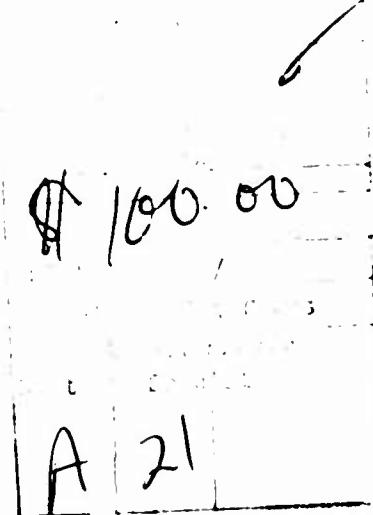
The introduction of the mini-computer into the dynamics test laboratory has made it possible to use several forms of multi-frequency excitation to speed up and simplify modal testing. These techniques have been described in the recent literature which has revealed that some of these forms of excitation are now used routinely in modal tests. A few of the earlier classical modal testing techniques have been upgraded and they are still in use. Therefore the test engineer has a wider choice of testing techniques and this could lead to difficulties in selecting the proper test method if several methods appear to be suitable. Thus published guidance for selecting proper modal test methods is needed.

This information need might be met in any of the following ways. Modal testing techniques have matured to the point where a review of all of the available methods might be published. It should include, but not be limited to, a description of the various methods, their advantages and limitations and their suitability for modal tests of various types of hardware. More published comparisons of the results of modal tests, using a number of different test methods, would be useful; in addition to the obvious comparison of the modal parameters and the ability to isolate all significant modes, other comparisons should be made.

These should include the ease of performing the test, the overall cost of testing, instrumentation requirements and the complexity of the data processing requirements. In 1976 a survey of modal testing practices was conducted. A number of factors were examined, such as the type of excitation, instrumentation, test article boundary and support conditions and many more. It is time to undertake a similar survey to see what changes in modal testing practices have occurred.

Any or all of the above steps would be helpful in defining the state of the art of modal testing, but more importantly, they would provide guidance for selecting a testing technique, or techniques, that would be the most suitable for the job. This is important because use of the wrong test method could lead to confusing and/or meaningless results.

R.H.V.



# EDITORS RATTLE SPACE

## THE DECLINE OF APPROXIMATE METHODS - ITS IMPLICATIONS FOR COMPUTATION

The decline in the development of approximate analytical techniques for solving engineering problems has been virtually unnoticed in this era of computers. Prior to the widespread availability of computers and programmable calculators, engineers depended on ingenious mathematical expressions, identities, series, and asymptotic expansions to solve many vibration problems. The need for answers to design problems was an important factor in the evolution of these techniques. Today no matter how large or small the problem the standard procedure is to "put it on the computer."

The extensive use of the computer has stymied the development and use not only of approximate methods but also of unique models of problems. No longer are such interesting and valuable contributions as the phase plane method and Duffing's method being made for specific classes of problems. These methods provided not only approximate solutions to problems but also insight into physical phenomena. The loss of insight as a result of the popularity of computer solutions is my greatest criticism of the current use of the computer.

Approximate analytical solutions to mathematically modeled problems provided both immediate solutions and the basis for many of the numerical techniques now used routinely on the computer. It is for this reason that I believe there will be a resurgence of activity in developing approximate methods. Of course, numerical techniques have their limitations and can be pressed only so far before problems in round off error and instabilities arise. But when better solutions are required at low cost, numerical methods will again be recognized as the important analytical tools they are.

R.L.E.

## DYNAMIC RESPONSE OF FLUID-FILLED SHELLS - AN UPDATE

F.L. DiMaggio\*

**Abstract.** This article reviews papers concerned with the dynamic response of shells containing fluid that were published during the past three or four years. Papers concerned only with effects of gravity (sloshing) or fluid flow are not included.

This paper is a continuation of two earlier reviews [1, 2]. With one exception the investigations discussed were published during the past three or four years. As in the past, papers dealing solely with sloshing or flow-induced vibrations are not considered.

### STRUCTURES OF ARBITRARY GEOMETRY

Several general presentations of methods for determining the natural frequencies of coupled vibrations of an arbitrary elastic structure containing inviscid fluid have appeared [3-5]. Finite element methods and their variational origins are the basis of some work [3, 4]. Closed structures filled with a compressible fluid have been considered [3]. Displacements were used in the fluid and structure as nodal variables to obtain symmetric, banded matrices that permit the use of classical eigenvalue solution methods. Spurious circulation modes, usually obtained when a purely displacement formulation is used, were suppressed by imposing irrotationality via a penalty function. Numerical results were presented for two-dimensional motion with rigid rectangular and circular cavities and for a rectangular cavity with three rigid walls and one simply supported elastic plate.

Both closed, filled structures and open, partially filled ones have been accounted for in other work [4]. The basic variables were taken to be displacements of the structure and pressures and displacement potential for the compressible fluid. Only

hydroelastic modes, as opposed to sloshing modes in a rigid tank, were considered, but extension to include these appeared to be relatively straightforward. A direct finite element method was first presented using these mixed nodal variables. Despite assertions to the contrary [3], a symmetric formulation was obtained. The substructuring scheme used as components - e.g., for the partially filled open shell - the hydroelastic modes with an incompressible liquid and the acoustic modes of a compressible fluid in a rigid tank. Numerical results for a filled, bowl-shaped tank with three clamped flanges demonstrated that the substructure technique is much more efficient than the direct method.

An integral equation method was used to study the free two-dimensional vibrations of an elastic beam cantilevered from the inside of a rigid cavity filled with incompressible liquid [5]. Expressions for beam displacements and the fluid velocity potential were obtained, and several properties of the solution were presented. No numerical example is given. Although the author states that extension to the three-dimensional case of an elastic container with arbitrary internal elastic structures is possible, it appears doubtful that an efficient numerical algorithm would result.

### CYLINDRICAL SHELLS

**Finite single shells.** Interest in the determination of the response of liquid storage tanks to earthquake excitation has led to several recent investigations of free and forced vibrations of circular cylindrical elastic tanks of finite height filled or partially filled with a fluid [6-9].

An open circular cylindrical shell with a fixed base and longitudinally varying thickness, partially filled with an inviscid, compressible liquid, has been as-

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sumed to undergo harmonic motion [6]. Membrane shell theory was used to obtain frequency-dependent virtual masses for each circumferential mode  $n$  for assumed longitudinal variations of shell displacements. For the beam mode  $n = 1$ , overturning moment and longitudinal and circumferential stress were also obtained. Results compared favorably with experimental results obtained earlier by others.

A combined experimental and analytical study of an aluminum open tank with rigid bottom partially filled with water has been presented [7]. Experimental studies involved shell and liquid responses to horizontal and vertical excitations of the bottom; both sinusoidal and scaled seismic time histories were taken. On the basis of these tests an approximate procedure was developed for predicting maximum circumferential and longitudinal stress in the tank wall during earthquakes. When only the  $n = 0$  (breathing) and  $n = 1$  modes were assumed to contribute, good comparison with experiments was obtained for the circumferential strain, but predictions of longitudinal root strain were overly conservative.

Sensitivity of lateral flexural wall motion to vertical excitation has been reported [7]. This has also been attributed to out-of-roundness of the shell [8]. Donnel's equations for a simply supported shell and a compressible fluid subjected to a vertical excitation at the base were used to obtain approximate expressions for lateral wall displacements for small distortions. The author claims reasonable agreement with experimental results obtained earlier by others. It should be noted that the boundary condition at the tank base, which states that the pressure is a Dirac delta in space (implying zero pressure over the fluid surface except at the origin), does not appear to be realistic.

Natural frequencies of the modes of combined axisymmetric motion of a liquid-filled tank with rigid sides, an elastic bottom, and an elastic floating roof have been obtained [9]. Numerical examples were used to illustrate the coupling.

**Coaxial shells.** A series of papers [10-14] involving coaxial shells with fluid between them have apparently been motivated by nuclear reactor components. Two coaxial circular cylindrical shells with open tops, elastic walls, and rigid bottoms have been considered [10]. Both the inside of the inner tank and the space

between tanks were partially filled with a compressible, inviscid fluid. A Rayleigh-Ritz method and finite differences were used to obtain expressions for both axisymmetric ( $n = 0$ ) and nonaxisymmetric ( $n \geq 1$ ) modes of coupled free vibration. A few numerical results for non-sloshing modes were presented. The authors stated that, for the case  $n = 0$ , results are essentially the same as those obtained in an earlier study assuming the fluid incompressible.

In an extension of a previous investigation [15] exact and approximate equations for the natural frequencies and damping ratios of the beam modes ( $n = 1$ ) of coupled motion of coaxial elastic tubes with incompressible, viscous fluid between them have been obtained. Extensive numerical results were presented for a series of simply supported tubes.

Finite elements have been used to obtain the added mass and damping coefficients of an incompressible viscous fluid between a circular cylindrical rod vibrating in a prescribed manner and a circular cylindrical enclosure [11]. Numerical results presented for a single rigid rod in a rigid enclosure agree with the known exact solution, numerical results were also given for two identical rigid rods vibrating in opposite directions. A similar procedure for hexagonal rods inside circular cylinders has been presented [12].

The beam response ( $n = 1$ ) of two elastic coaxial cylinders with fixed or free bases and tops and filled with incompressible, inviscid liquid between them has been considered [13]. The cylinders were modeled by a vertical array of springs and lumped masses to which were added virtual masses to account for the fluid. Displacement response to base excitations were obtained using standard modal superposition. Four examples were considered, each with two base inputs. In each example four masses were used to model each cylinder.

The transient response of two infinite circular cylindrical elastic shells coupled by an inviscid, compressible fluid to a plane pressure pulse has been investigated [16]. Laplace transforms were used to obtain exact integral expressions for the solution. Numerical results presented for steel shells in water demonstrated that, for the material and geometrical parameters considered, the outer shell was very transparent to the incident wave.

**Infinite single shells.** The problem of blood flow has been addressed [17-19]. Dispersion relations for axisymmetric flexural (Young) wave propagation through fluid-filled, circular cylindrical, flexible tubes of infinite extent were studied.

In an excellent early paper [17] waves in an incompressible viscous fluid inside an elastic or viscoelastic membrane were investigated. Approximate closed form expressions for phase velocity and damping factor were obtained for various limiting cases.

Dispersion in an inviscid, incompressible fluid inside an elastic thin-walled tube has been treated approximately [18]. The author's references are not current and do not include any important recent papers on this subject.

New developments regarding this problem have been reported [19]. The theory of small deformations superimposed on finite deformations was used to include the effects of initial longitudinal pretension and circumferential muscle tension. In this study the arteries (shell) were assumed to be incompressible nonlinear orthotropically elastic membranes; blood was considered an incompressible viscous fluid.

### SPHERICAL SHELLS

The procedure used for cylindrical shells [16] was used to solve the problem of two fluid-coupled concentric spherical shells subjected to an incident plane wave [20]. The same conclusion is reached; i.e., for thin steel shells containing water the exterior shell is essentially transparent to the incident pulse.

Modes and frequencies for open hemispherical elastic shells partially filled with a liquid have been obtained experimentally with the upper rim both free and fixed [21]. In the tests performed the effect of the fluid on shell vibrations was considerable for the clamped top but negligible for the free edge. Comparison of experimental results with a finite element analysis indicated good agreement.

### MISCELLANEOUS

Investigations of head injury commonly involve the study of fluid-filled shells [1]. A thick prolate

spheroidal viscoelastic shell was used to model the scalp and a viscoelastic fluid approximated the brain [22]. Finite differences were used to obtain the response to simulated head impacts with various time histories. The boundary conditions used on the inner surface of the shell, however, were incorrect. Thus, because the problem appears not to be well posed, the results obtained are suspect.

It appears that two very similar models have been used [22, 23]. Finite elements were used to study both cavitation and shear damage due to impact [1]. It was concluded that the addition of fluid viscosity has little effect and that occipital head shocks produce higher stresses than frontal impacts.

A combined analytical and experimental approach to the study of vibrations of partially filled box-like fuel tanks has been vaguely discussed [24].

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# LITERATURE REVIEW

survey and analysis  
of the Shock and  
Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains an article about vibrations of conical shells.

Professor C.H. Chang of the University of Alabama has written a literature review of the vibrations of conical shells. The various formulations and solutions of free and forced vibrations of axisymmetric and asymmetric modes of isotropic and anisotropic conical shells are summarized. Computer programs available for computation of the frequencies and mode shapes of vibrations of conical shells of any configuration are discussed.

## VIBRATIONS OF CONICAL SHELLS

C.H. Chang\*

**Abstract.** A literature review of the vibrations of conical shells is presented. The various formulations and solutions of free and forced vibrations of axisymmetric and asymmetric modes of isotropic and anisotropic conical shells are summarized. Computer programs available for computation of the frequencies and mode shapes of vibrations of conical shells of any configuration are discussed.

Early interest in vibration of conical shells involved determination of the frequencies and mode shapes of vibration of loudspeakers [1-6]. Few research reports were available before the coming of the space era. At that time demand for knowledge about the strength and other dynamic characteristics of conical shells increased because conical shells were widely used in various parts of space vehicles. Extensive literature reviews are available [7-10], including an excellent comprehensive review by Leissa [11].

The majority of research on the vibrations of conical shells has been devoted to the basic problem of linear free vibration. Thus, except at the end of this review where subjects other than free vibration are briefly discussed, this paper focuses on the free vibration of isotropic and elastic cones.

### FORMULATIONS

On the basis of Love's assumptions of first approximation [12, 13], the equations of motion of vibration for a shell element were derived either by using Newton's second law of motion by applying d'Alembert's principle to the equations of equilibrium [14-16], or by applying the Hamilton principle through the variational method [17, 18]. The last approach provides a set of geometric as well as natural boundary conditions.

Improved theories based on Love's are available [11, 12]. A numerical comparison between Love's theory and an improved Naghdi's theory [19] for free axisymmetric vibration of cones has been made [20]. The improved theory yielded lower frequencies; the difference, however, was insignificant. The Love theory has been used by the majority of the researchers.

The basic equations have been presented in general curvilinear coordinates for the middle surface of a shell [14-17]. These equations are first converted to a shell of revolution and then to a conical shell. The circumferential coordinate  $\theta$ , meridional distance  $s$  (measured from the apex of a cone along a generator), and normal coordinate  $z$  (from the middle surface) are usually used for conical shells having the half vertex angle  $\alpha$  as a parameter.

Hu [21] included the effects of the transverse shear deformation and rotatory inertia in the meridional direction; he presented a set of working formulations for the linear theory: three equations of motion, two equations of rotatory motion, and eight constitutive equations. These 13 equations are for the following 13 unknowns: three stress resultants,  $N_s$ ,  $N_{\theta}$ ,  $N_{\theta\theta}$  ( $=N_{\theta\theta}$ ); two transverse shearing forces,  $Q_s$ ,  $Q_{\theta}$ ; three moments,  $M_s$ ,  $M_{\theta}$ ,  $M_{\theta\theta}$  ( $=M_{\theta\theta}$ ); two rotatory angles  $\beta_{\theta}$ ,  $\beta_s$ ; and three displacements,  $u$ ,  $v$ , and  $w$  in the directions of  $\theta$ ,  $s$ , and  $z$ , respectively.

A cone frustum has two ends: the small end (S) is located at  $s=s_1$ ; the large end (L) is at  $s=s_2$ . When  $s_1=0$ , the structure is known as a complete cone. Each end has five homogeneous boundary conditions [21].

When the effects of transverse shear deformation and rotatory inertia are neglected,  $\beta_{\theta}$  and  $\beta_s$  are no longer independent functions; rather, they are functions of  $w$ , the normal derivative of  $w$ , and 11 equations exist

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for 11 unknowns [11]. Four homogeneous boundary conditions are at each end. With this approach the transverse shear forces are combined with twisting moments  $M_{s\theta}$  to form Kirchhoff's effective shearing forces [22]. This is known as the classic bending theory.

For very thin shells, the bending effect can be neglected. In this simplified case, both the moments and the transverse shear forces vanish. There are three equations of motion and three constitutive equations for three membrane stresses  $N_s$ ,  $N_\theta$ ,  $N_{s\theta}$  and three displacements  $U$ ,  $V$ ,  $W$  [23]. The system can be reduced to three equations of motion in terms of three displacements for both the membrane and bending theories [10, 11, 14].

When the inertia terms and the transverse shear forces in the equations of motion in the  $\theta$  and  $s$  directions are neglected, the two equations are reduced to equilibrium equations. They can be identically satisfied by introducing the Airy stress function  $\phi$  for the stresses. A compatibility equation and the equation of motion in the  $z$  direction form the two coupled Donnell-type equations for the two unknown functions  $\phi$  and  $w$  [24]. A set of nonlinear Donnell-type equations has also been derived [18].

First order equations for both axisymmetric [25] and asymmetric [26] modes are available for numerical iteration methods. Hu [21] has derived a set of 13 first-order equations containing 13 unknowns but having only ten first-order derivatives - thus only ten boundary conditions are needed. The effects of shear deformation and rotatory inertia are included.

## SOLUTIONS FOR FREE VIBRATION

The three variables  $\theta$ ,  $s$ , and time  $t$  are separable in the system of partial differential equations. The equations have variable coefficients and are very difficult to solve for exact solutions. With the exception of solutions for a couple of very special cases of membrane vibration, all available solutions have been obtained by approximate numerical methods, e.g., the Rayleigh-Ritz method [28-37], Galerkin procedure [9, 10, 21, 38-42], finite difference [43-47], iteration method [21, 25-27], asymptotic technique [48], and the finite element method [49-52].

Neglecting the effects of shear deformation and rotatory inertia solution for the three displacements of the three equations of motion can be given in the following forms:

$$u = \sum_n u_n(s) \sin n\theta e^{iqt}$$

$$v = \sum_n v_n(s) \cos n\theta e^{iqt} \quad (1)$$

$$w = \sum_n w_n(s) \cos n\theta e^{iqt}$$

in which  $i = (-1)^{1/2}$ ,  $q$  is the circular frequency,  $n$  is an integer, the circumferential wave number, and  $u_n$ ,  $v_n$ , and  $w_n$  are functions of normal modes to be determined.

## AXISYMMETRIC VIBRATIONS

For the simpler axisymmetric case,  $n=0$  in the solutions of equations (1). Thus the circumferential displacement  $u$  can be separated from the other two. The three displacement equations reduce to one equation for  $u$  and two coupled equations for  $v$  and  $w$  [53].

**Torsional vibration.** The single equation for  $u$  is due to the tangential inertia force, which causes torsional vibration. This equation is a second order Sturm-Liouville equation, and the exact solution has been obtained [53]. For conical shells, the solutions are in Bessel functions [53, 54]. Frequency spectra for various end conditions have been obtained [54]. The eigenfrequency  $f$  was given in the form

$$f = \ell q \sqrt{\rho/G} \quad (2)$$

in which  $\ell = s_2 - s_1$ ;  $\rho$  is the mass density, and  $G$  is the shear modulus [43, 53, 54]. The  $f$  value approached asymptotically the frequencies of the torsional vibration of a prismatic bar with proper end conditions [55].

**Transverse vibration.** The power series method has been used [56] to solve the two coupled equations for  $v$  and  $w$ . Because of the question of convergency the solutions were classified as approximate [32].

Solutions based on the first order equations have been obtained [25-27] with agreeable numerical examples.

Dreher and Leissa [57, 58] used the power series method for Donnell-type equations. Frequencies of a wide range parameter were presented.

The lowest frequency for cones and ojival shells was determined by a combination of a membrane theory with the longitudinal inertia neglected and a boundary layer theory for the bending [48]. This asymptotic approach has also been used for shells of revolution [59]. However, it has been noted [60] that some results [48] are only for limited special cases.

**Meridional vibration.** Membrane vibration due to meridional or longitudinal inertia force has been studied by various approaches [23, 61, 62]. A set of exact solutions of asymmetric vibration has been obtained [23]. For cones with a boundary condition  $N_{30} = 0$  the frequencies obtained [23] were identical to those of axisymmetric cones [61]. These frequencies can be combined into one diagram as shown in the figure;  $R_1$  and  $R_2$  are radii at  $s=s_1$  and  $s_2$ , respectively. The eigenfrequency was given as

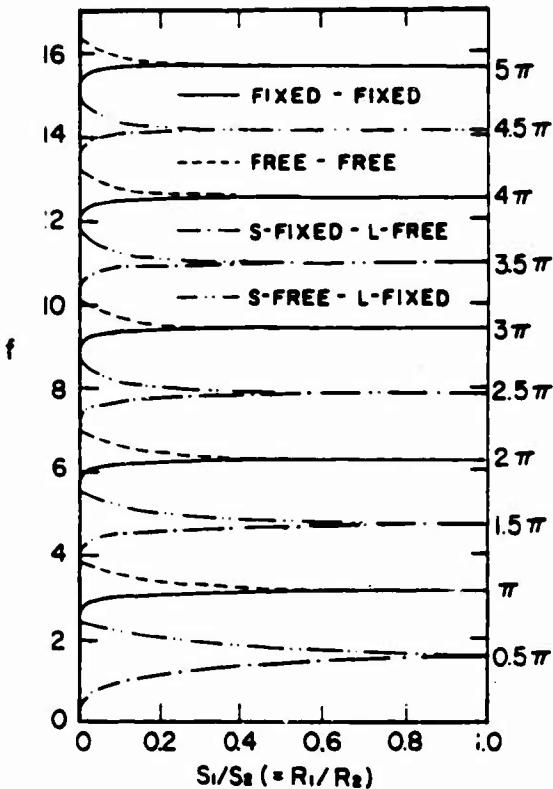
$$f = \frac{L}{2} \sqrt{\rho/E} \quad (3)$$

This  $f$  value approached the frequencies of the longitudinal vibration of bars as the limits [55].

**Effects of shear deformation and rotatory inertia.** Effects of shear deformation and rotatory inertia have been studied [20, 63] only for axisymmetric modes. The shear deformation lowered the frequencies; this effect was greater for thicker, shorter, and smaller apex angle cones for transverse vibrations. The effect of rotatory inertia due to axisymmetric modes was insignificant. The effects of shear deformation and rotatory inertia on axisymmetric torsional frequencies were also insignificant [63].

## ASYMMETRIC VIBRATIONS

Asymmetric free vibrations have been studied by the inextensional theory [1]. In some cases both extensional and inextensional effects are included [31]; in other cases the two effects are treated separately



Frequencies of Membrane Meridional Vibration

[35]. A mathematically comprehensive investigation has been made [8], as have many other studies [9, 10, 46, 64].

Most of the numerical results compared well with experiments. The following observations were made from these investigations [8-10, 35, 46, 64].

- the lowest frequency of an axisymmetric mode of a cone did not represent the lowest or fundamental one. The lowest frequency depended, in addition to the geometric property and boundary conditions, also on the number of circumferential modes  $n$
- the frequencies of the extensional or membrane vibration decreased as  $n$  increased, that of the inextensional or bending vibration increased monotonically as  $n$  increased
- for small values of  $n$  the membrane effect on frequencies was significant. As  $n$  increased this effect diminished and the bending action dominated

- if the two effects, membrane and bending, were calculated separately for simplicity, the resultant frequencies could be computed by the following equation [8, 35]:

$$f^2 = f_E^2 + f_I^2 \quad (4)$$

in which  $f_E$  and  $f_I$  are frequencies of extensional and inextensional vibrations, respectively. The minimum frequency for a fixed mode in the  $s$ -direction could be located where  $f_E = f_I$

- the  $n$  number of the minimum frequency of a mode in the  $s$  direction increased as the number of modes in the  $s$  direction increased
- the maximum displacement or the antinode of a mode shape in the meridional direction shifted toward the larger end of a cone as  $n$  increased

An investigation of the frequencies of different modes in the  $s$  direction and the  $n$  values for free-free cones has been made [37]. Examples of vibrations of conical shells connected to cylindrical or spherical shells have been given [27]. As mentioned earlier, exact solutions of axisymmetric membrane meridional vibrations have been obtained [23], but no numerical examples were given for the asymmetric case.

Ueda [65] studied the nonlinear free vibration of a simply supported conical shell by the finite element displacement method. He found that the nonlinear effect softened the shell and that the frequencies decreased as amplitudes increased. However, for cones simply supported and completely restrained at both ends, Sun [66] found that the nonlinear effect made a cone behave as a hard spring.

### ANISOTROPIC AND ORTHOTROPIC CONES

Free vibration of anisotropic conical shells has been investigated [67]. Bert and Rag [68] presented the two lowest frequencies of unsymmetric modes of free-free orthotropic sandwich conical shells. Based on a first order equation [27], Cohen [47] presented an iteration method for studying the asymmetric vibration of ring-stiffened shells of revolution. Other work has been reported [69-75].

### FORCED VIBRATION AND DYNAMIC STABILITY

Transient response and forced vibrations of cones have been investigated for a constant velocity pressure [76, 77] and for a moving pressure [78]. Vibration of cones subjected to sudden heating has also been studied [79]. The behavior of the linear and nonlinear stability of cones due to sinusoidal change and due to a ramp-type change of temperature has been reported [66, 80].

Donnell-type equations were used to conduct several studies on the dynamic stability of conical shells. The Galerkin procedure was used under periodic axial load [81] and under periodic external pressure [82] for four sets of cones of different boundary conditions. Finite difference was used for a cone with both ends clamped under step axial pressure [83].

Dynamic stability has also been investigated for cones under pulsating pressure [84], under longitudinal forces and a uniform external pressure [85] and under transversal and longitudinal forces with nonlinear material damping [86]. The elastic response of a cone to an oblique impact has been studied using a finite difference method [87]. Vibration and flutter tests of a pressurized nose cone at Mach number 3 have been reported [88], as have other studies concerning forced vibration and flutter [89-93].

### COMPUTER PROGRAMS

A computer program based on the finite element method for vibration modes and frequencies of orthotropic thin shells of revolution having general meridional curvature has been reported [50]; two examples of conical shells were used. Another computer program known as ASBRIL [94] has been used to analyze axisymmetric vibrations of conical shells. The influence of length, thickness, apex angle, and boundary conditions was examined by 3000 different configurations [49]. Finally, a general and comprehensive computer program designated BOSOR4 for stress, buckling, and vibration of complex shells of revolution is available [95]. This program can be used for linear or nonlinear analysis of shells of revolution, it can also be used for axisymmetric or

asymmetric loading and isotropic or anisotropic materials.

## SUMMARY

The survey was made from the literature in English. The available reports covered most aspects of the subject area except two: vibrations with time-dependent boundary conditions and the effect of interactions between the shell and the surrounding media on vibrations of conical shells.

Numerous reports are available, but the problem is far from completely solved. For instance, a number of different expressions are used for the parametric frequency of transverse vibration; the expressions differ in characteristic length and in material constants [11]. Equations (2) and (3) might suggest that slant length would be a better choice for length. These two equations also indicate that the frequencies of torsional, meridional, and hence transverse vibrations are functions of different material and geometric constants; their unification in coupled vibrations needs further analytic investigation.

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# BOOK REVIEWS

## NUMERICAL MODELING OF DETONATIONS

C.L. Mader

University of California Press, Berkeley, CA  
1979, \$40.00

This book describes work on condensed explosives and solutions to differential equations for reactive flow in one- and two-spatial dimensions using finite-difference computer codes. The work was done by the author and his colleagues at Los Alamos Scientific Laboratory over the last two decades.

Mader presents the results of computations of detonations in liquid explosives, nitromethane, and liquid TNT, with resolved steady reaction zones. An Arrhenius rate law and the HOM equation of state for the unreacted explosive, detonation products, and their mixtures were used. Structure of the reaction zone depends strongly on the properties of the mixture equation of state. Furthermore, the detonations are not steady in time. The pressure amplitude and reaction zone length oscillate. The detonation must be overdriven by the piston at the rear boundary in order to approach a steady state. Steady state is achieved only after the detonation wave travels many reaction zone lengths. The oscillations are believed to be inherent in the differential equations describing the flow and not in numerical artifacts.

The second chapter deals with equations of state for the detonation products. The author proposes use of the Becker-Kistiakowsky-Wilson (BKW) equation of state in the context of the Chapman-Jouquet (C-J) model of detonation for purposes of engineering calculation. He emphasizes the importance of a high particle density - i.e., high intermolecular potential energy density - for obtaining the most work from an explosive. Nonideal explosives, that is, those whose measured detonation parameters are significantly below values from equilibrium thermodynamic calculations, are seen in terms of incomplete reaction

in these mixtures near the wave front. This effect can be due to the formation of products with the effect of lowering the effective C-J temperature, hence inhibiting reaction. Mader treats buildup of detonation, i.e., the concept that effective C-J pressure increases as the wave runs at nearly constant velocity. The model and the experimental evidence on which it is based are still controversial. The questions are how unsteady is the detonation and how best to treat the unsteady character.

Initiation of detonation by thermal or shock stimuli is the subject of the next chapter. Mader has had some success in computing shock initiation in homogeneous explosives and demonstrating the efficacy of voids and high-density inclusions in forming hot spots. The model known as Forest Fire, for shock initiation in heterogeneous explosives, is described. It is based on the concept of single-curve buildup in conjunction with experimental data on distance of run to detonation as a function of input pressure - to obtain a pressure-dependent decomposition rate function. Application of this model to problems in propagation and failure of detonation in several geometries has led to the conclusion that failure in heterogeneous explosives is dominated by the same hot-spot decomposition mechanism as is shock initiation. Burning to detonation is also treated.

Finally Mader compares computational results with experimental results for a number of geometries of detonating explosive interacting with inert materials. Comparison shows the importance of including metal properties such as strength, viscosity, and spall criteria in calculations. Two-dimensional Eulerian calculations of plate dent and plate push experiments are discussed, as are detonations underwater.

The book concludes with extensive appendices that provide details concerning differencing the flow equations in one and two dimensions in both Lagrangian and Eulerian coordinates. Equation-of-state forms for HOM, BKW, LJD, ideal gas, and Debye-solid models are given.

The book contains many tables of material properties for explosives and the inerts with which they interact. C-J thermodynamic values and product compositions are given, as are release isentropes and ideal gas thermodynamic properties of detonation products for a great number of gases. A minor criticism is that units for the material property numbers are not given in several of the tables. At times the text is more terse than one would like. On occasions the word isentrope is used where adiabat is meant. The book should be very useful to persons computing reactive flow problems. There is a wealth of information that anyone working in detonation research and development might wish to consult.

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### STRUCTURAL MECHANICS SOFTWARE SERIES, VOLUME III

N. Perrone and W. Pilkey, Editors  
University Press of Virginia, Charlottesville, VA  
1980, 344 pages, \$25.00

This is the third volume of this review-and-assessment series. The three parts of this volume cover 11 structural analysis subjects and provide information on sources of engineering literature and computer programs.

The first part of the book briefly restates the availability and range of applicability of the 13 programs reviewed in the first two volumes: SAP V (general three-dimensional linear structural analysis), UCIN (crash analysis), WHAMS (nonlinear transient structural analysis), DISK (analysis of thick elastic disks, cylinders, and spheres), TWIST (analysis of torsional systems), GRILL (grillage analysis), TABS 77 (elastic analysis of frame and shear wall buildings), BOSOR4 (analysis of shells of revolution), GIFTS (finite element analysis with interactive graphics), PREM-SAP (interactive preprocessor for SAP), BEAM (flexural analysis of beams), BEAMSTRESS (computation of beam section properties), and SHAFT (computation of flexural response and critical speed of

rotating shafts). It also describes new developments for SAP, GIFTS, and BOSOR and presents two potentially useful lists: 10 computerized data bases of engineering abstracts and 22 computer program users' groups and software dissemination services.

The second part of the book contains reviews and summaries of programs in eight subject areas: multi-point boundary value problems, pile foundation analysis and design systems, general purpose nonlinear finite element programs, rotor dynamics, stiff differential equation systems, ship hull vibration analysis and design, piping engineering, and fracture mechanics. In each section the authors first discuss various aspects of the subject area and, in some cases present typical solution techniques, and then describe the applicable programs.

The final part of the book presents in-depth discussions of three technological areas. The first area, finite element mesh optimization and enrichment techniques, is concerned with optimally arranging a given number of finite elements or optimally refining a finite element mesh. The second area, mixed methods analysis, is concerned with formulations of structural problems in which the fundamental unknowns include both stress and kinematic variables. The final section discusses various damping models.

The book is generally well written and can be a valuable reference not only for those whose interests lie in the subject areas of the second and third parts but also for those searching for sources of engineering abstracts and programs.

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### FLOW INDUCED VIBRATIONS

S.S. Chen and M.D. Bernstein, Editors  
ASME, New York, New York, 1979, 152 pages

The book is a collection of 17 papers presented at the Third National Congress on Pressure Vessel and

Piping Technology held in San Francisco, June 25-29, 1979. The topics covered are: vortex-excited vibrations of single and multiple tubes due to cross flow; wake-induced flutter; fluid damping; dynamics and analysis of tubes conveying fluids; nuclear fuel-rod vibrations; self-excited vibrations on gates, valves, and seals; and acoustic vibrations.

The most common problem in flow-induced vibrations, namely vortex-excited cross-flow vibrations, is discussed in the first six papers. O.M. Griffin's article, "Vortex-Excited Cross Flow Vibrations of a Single Cylindrical Tube" describes experimentally obtained response behavior of elastically supported circular cylinders in cross flow and cites fluid forces either measured or deduced from experiments; in addition a proposed mathematical model is well supported by a wide range of independent experimental investigations. The effect of damping on vortex-induced vibrations of simply-supported horizontal tubes partially filled with water is reported by D.J. Johns and G. Skordilis in "Vortex Excitation by Transverse Flow of Simply-Supported Tubes Containing Fluid." A different type of fluid damping - external fluid dynamic dissipation damping - and its effect on the whirling instability of tube arrays in cross flow is addressed by R.D. Blevins in "Fluid Damping and the Whirling Instability of Tube Arrays." The problem of aeroelastic stability of two cylinders in tandem is discussed by Y.T. Tsui and C.C. Tsui in "On Wake Induced Flutter of a Circular Conductor in the Wake of Another." It is refreshing to see the problem of flow-induced vibrations on heat exchangers addressed from an external flow field point of view, as was carried out by M.M. Zdravkovich and J.E. Namork in "Structure of Interstitial Flow between Closely Spaced Tubes in Staggered Array." A very useful problems-solutions oriented contribution by F.L. Eisinger entitled "Prevention and Cure of Flow-Induced Vibrations Problems in Tubular Heat Exchangers" discusses various methods for predicting and solving tube and acoustic vibration problems.

The topic of flow-induced vibrations of tubes conveying fluids is discussed in two articles. The contribution by E.C. Ting and J.L. Kanning, "Dynamics of Flow-Conveying Pipe Structures," presents novel numerical techniques for the solution of the dynamic analysis of fluid-conveying pipe structures. A mathematical model capable of describing the nonlinear

behavior of fluid-conveying tubes is discussed by E. Ch'ng and E.H. Dowell in "A Theoretical Analysis of Nonlinear Effects on the Flutter and Divergence of a Tube Conveying Fluid."

Two contributions deal directly with vibrations of reactor core assemblies. C.D. Henry et al in their article "Flow-Induced Vibrations in GCFR Core Components" review several methods for predicting flow-induced vibrations on rods and ducts of the GCFR core and suggest an experimental plan to study such vibrations. A stochastic analysis technique for interpreting and analyzing experimental vibration test results on pressurized water reactor nuclear fuel assemblies is developed by W.J. Bryan in "Digital Analysis Techniques Used in Nuclear Fuel Vibration Analysis."

Flow-induced vibrations on valves and gates are discussed in two papers. The article, "Failure of Safety Valves due to Flow-Induced Vibration" by J.T. Coffman and M.D. Bernstein addresses a specific sonic vibration problem that occurred on reheat safety valves of a gas-fired steam generator. A general theoretical model for the prediction and study of self-excited vibrations of valves subject to jet flow instability is presented by D.S. Weaver and S. Ziada in "A Theoretical Model for Self-Excited Vibrations in Hydraulic Gates, Valves and Seals." This paper also presents results of a parametric study in which the dependence of vibrational amplitude and discharge characteristics on structural stiffness, fluid inertia, discharge coefficient, and other variables is shown. Some experimental results in support of Weaver's model are given.

Vibrations induced by condensation occurring in nuclear power plants is the subject of two contributions. R.S. Samra in "Feedwater System Transient Analysis for a PWR" discusses an analytical method for analyzing water hammer that occurs in feedwater systems due to condensation. Short duration pressure pulses with peak values of 22 MPa can occur in the system. The article, "The Distribution of Pressure Amplitudes during Chugging," by G.B. Andeen and J.S. Marks addresses the phenomenon of bubble growth and the subsequent rapid collapse (called chugging) that occurs when steam is injected into subcooled water.

C.I. Yang and T.J. Moran present a method for calculating the hydrodynamic reactions of harmonically

oscillating arrays of hexagonal cylinders in "Calculations of Added Mass and Damping Coefficients for Hexagonal Cylinders in a Confined Viscous Fluid." Finite element analysis is used by A.N. Nahavandi and R. Falsafi-Haghghi in "Interaction between Structures and Fluids" to develop a numerical model for solid-fluid interaction; the model is applied to two-dimensional channel flow with elastic walls and is compared to a previous study based on the finite element discretization of the two-dimensional wave equation.

In summary, the book *Flow Induced Vibrations* is a good state-of-the-art account of important research and development activities in the field.

D.W. Sallet  
Department of Mechanical Engineering  
The University of Maryland  
College Park, Maryland 20742

# SHORT COURSES

## JUNE

### COMPUTER-AIDED DESIGN OF DYNAMIC SYSTEMS

Dates: June 15-19, 1981

Place: East Lansing, Michigan

Objective: This course presents a structured approach to model building, formulation of state equations, and computer-aided analysis of the models. Applications are drawn from mechanical, electrical, hydraulic, thermal, and mixed-energy systems.

Contact: Dr. Ronald C. Rosenberg, Program Director of the A.H. Case Center for Computer-Aided Design, College of Engineering, Michigan State University, East Lansing, Michigan 48824 - (517) 355-8296.

### COMPUTER-AIDED METHODS FOR MODAL ANALYSIS

Dates: June 22-26, 1981

Place: East Lansing, Michigan

Objective: This course introduces both finite elements and modal testing, emphasizing this common theory and pointing out the particular advantages of each method. Hardware includes the GenRad 2507, the Hewlett Packard 5423, and the PRIME 750. Software includes ANSYS, MODAL PLUS, and SUPERTAB.

Contact: Dr. James E. Bernard, Director for the Case Center for Computer-Aided Design, College of Engineering, Michigan State University, East Lansing, Michigan 48824 - (517) 355-6453.

### MECHANICS OF HEAVY-DUTY TRUCKS AND TRUCK COMBINATIONS

Dates: June 22-26, 1981

Place: Ann Arbor, Michigan

Objective: The heavy truck or truck combination is a complex pneumatic-tired system. This course presents analysis programs, parameter measurement

methods and test procedures useful in understanding and designing a vehicle. The course describes the physics of heavy-truck components that determine the braking, steering and riding performance of the total system.

Contact: University of Michigan, College of Engineering, Continuing Engineering Education, 300 Chrysler Center, North Campus, Ann Arbor, Michigan 48109 - (313) 764-8490.

### FUNDAMENTALS OF NOISE AND VIBRATION CONTROL

Dates: June 22-26, 1981

Place: Cambridge, Massachusetts

Objective: This one week program is designed to provide a background in those aspects of sound and vibration that are important to noise control engineering. The general approach will be based on engineering concepts rather than theoretical analysis. The program is designed for the working engineer who has become involved in noise problems and seeks to deepen his/her understanding of the subject.

Contact: Director of Summer Session, Room E19-356, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139.

### OPERATIONAL AVAILABILITY AND MAINTAINABILITY ENGINEERING

Dates: June 22-26, 1981

Place: University of California - Los Angeles

Objective: To cover the following subjects: The equipment reliability, maintainability and availability interrelationships. The design of equipment to maximize their accessibility and minimize their downtime. Determination of equipment downtime, time-to-restore distribution, and mean maintenance man-hours per operating hour; spare parts requirements at a desired confidence level and spares optimization. Preventive maintenance policies and the quantification of the resulting increase in the reliability of maintained equipment. Determination of

the optimum preventive maintenance schedule of equipment to minimize their total corrective and preventive maintenance cost. Quantification of reliability and availability of maintained equipment considering their failure and repair rates. Determination of the various steady state availabilities of equipment and systems. The planning, execution, data acquisition, and data analysis of equipment maintainability demonstration tests.

Contact: Mr. Robert Rector, Assistant Director - Short Courses, UCLA, 6266 Boelter Hall, Los Angeles, CA 90024 - (213) 825-3496/1295/3344.

## JULY

### **12TH ANNUAL INDUSTRIAL PRODUCT NOISE CONTROL INSTITUTE**

Dates: July 6-10, 1981  
Place: Schenectady, New York

Objective: For engineers, designers, environmental health specialists and managers concerned with noise and vibration control. This course will provide information on the theory, measurement and economics of noise reduction. It will cover the latest information on the nature of sound and noise control, including noise criteria, airborne sound distribution, vibration control, and noise signature analysis. Other topics include how noise is produced by different types of engineering equipment such as compressors, electric motors, fans, valves, and transformers.

Contact: Union College, Graduate Studies and Continuing Education, Wells House - 1 Union Ave., Schenectady, New York 12308 - (518) 370-6288.

### **6TH ANNUAL APPLIED INSTRUMENTATION AND MEASUREMENTS ENGINEERING**

Dates: July 6-10, 1981  
Place: Schenectady, New York  
Objective: Designed for technicians, engineers and managers involved in the field of instrumentation and measurements. It will present a comprehensive view of the instrumentation system from transducer to readout, including a major emphasis on computer interfacing techniques. Principal topics will include:

philosophy of measurements, transducer operating principles and selection criteria, static and dynamic data acquisition systems, occurrence and prevention of noise in measurement systems, data reduction methods, digital techniques, and statistical treatment of data. "Hands-on" lab experience will be offered.

Contact: Union College, Graduate Studies and Continuing Education, Wells House - 1 Union Ave., Schenectady, New York 12308 - (518) 370-6288.

### **COMPUTER-AIDED DESIGN OF CONTROL SYSTEMS**

Dates: July 6-10, 1981  
Place: East Lansing, Michigan  
Objective: This course presents an introduction to time and frequency domain techniques for the computer-aided design of control systems. Both classical (transfer function) and modern (state variable) methods will be developed and applied, thus bringing participants up to current best practice.

Contact: Dr. Ronald C. Rosenberg, Program Director of the A.H. Case Center for Computer-Aided Design, College of Engineering, Michigan State University, East Lansing, Michigan 48824 - (517) 355-8296.

### **INSURANCE INDUSTRY SEMINAR**

Dates: July 7-9, 1981  
Place: Carson City, Nevada  
Objective: This course is designed for personnel from the insurance industry or self-insured companies who are responsible for inspection of plants that use large, high-speed rotating machinery. Features in the seminar include: discussion of the economics of machine monitoring and predictive maintenance, presentation of machine types that should be considered, and minimum standards necessary for effective machine protection diagnosis; information and the presentation of catastrophic failure by use of proper maintenance methods and malfunction diagnosis techniques; and survey of state-of-the-art methodology.

Contact: Kathy Fredekind, Bently-Nevada Corporation, P.O. Box 157, Minden, Nevada 89423 - (702) 782-3611, Ext. 224.

## **RELIABILITY ENGINEERING**

Dates: July 13-17, 1981  
Place: University of Chicago  
Chicago, Illinois

Objective: After completing this course, participants should be able to calculate the failure rates of components and products; construct their Reliability "Bath-Tub" curves; determine the early, chance, and wearout reliability of components; and determine from data the parameters of the times-to-failure distributions of components and products analytically and by probability paper plotting for the exponential and Weibull cases. They should also be able to determine equipment time-to-restore distributions, along with the reliability of systems of any complexity, including series, parallel, standby, load-sharing, multi-mode function and switching; and using Bayesian prediction, the confidence limits on the reliability for the exponential, Weibull, and binomial cases. Finally, participants will be able to determine the maintainability of equipment and the reliability and availability of maintained components, equipment, and systems of many levels of complexity.

Contact: Mr. Stod Cordelyou, Assistant Director, Continuing Engineering Education Program, The George Washington University, Washington, D.C. 20052 - (202) 676-6106, (800) 424-9773, Telex: 64374 (International).

## **PLANNING A DIGITAL DATA ACQUISITION AND CONTROL COMPUTER SYSTEM**

Dates: July 20-23, 1981  
Place: Schenectady, New York

Objective: The course covers the interconnection of a multitude of devices from sensors to final control elements with ultimate output of system conditions on the man-machine interface devices; the sensing of temperature, pressure, level, flow, speed, weight, torque, vibration and electrical parameters such as: volts, amps, watts, vars, power factor, frequency and motor load. The flexibility and utilization of data presentation via dynamic, colored graphic and tabular CRT displays, is presented as an optimum man-machine interface. System components/hardware and their interconnection are discussed in depth. Staging, on-site testing and as-built documentation are the final steps in the planning of a digital acquisition and control computer system.

Contact: Union College, Graduate Studies and Continuing Education, Wells House - 1 Union Ave., Schenectady, New York 12308 - (518) 370-6288.

## **12TH ANNUAL CONFERENCE ON FRACTURE MECHANICS I AND ITS APPLICATION TO FRACTURE CONTROL**

Dates: July 20-24, 1981  
Place: Schenectady, New York

Objective: Material covered will benefit anyone in an engineering related position who is concerned with the application of fracture mechanics to the prevention of brittle fracture such as pressure vessels for power generation, malleable iron castings, structural steel fabricated frameworks and ASME Pressure Vessel code applications. Included are: engineering approach to component failure; failure analysis of pressure vessels; fracture mechanics based toughness criteria in ASME Pressure Vessel code, examples and case histories of code fracture mechanics applications; elasto-plastic analysis; computer aids for calculating remaining cyclical life, crack initiation and propagation, life prediction, and non-destructive testing methods and capabilities.

Contact: Union College, Graduate Studies and Continuing Education, Wells House - 1 Union Ave., Schenectady, New York 12308 - (518) 370-6288.

## **RELIABILITY TESTING**

Dates: July 20-24, 1981  
Place: University of Chicago  
Chicago, Illinois

Objective: This course has been designed to enable participants to calculate the failure rates of components and products; determine the early, chance, and wearout reliability of components and products, and determine the parameters of distributions involved in the time-to-failure data of components and products analytically and by probability paper plotting, conduct Chi-Squared and Kolmogorov-Smirnov goodness-of-fit tests to determine the most appropriate distribution to use, learn to determine the confidence limits on the reliability for the exponential, normal, lognormal, Weibull, and binomial cases, determine the operating characteristic curves of components and products, plan, conduct, and analyze the results of sudden death, suspended-items, percent survival, success run, C-rank, and nonparametric

tests; and plan, conduct and analyze the results of sequential, Bayesian, and accelerated tests.

Contact: Mr. Stod Cordelyou, Assistant Director, Continuing Engineering Education Program, The George Washington University, Washington, D.C. 20052 - (202) 676-6106, (800) 424-9773, Telex: 64374 (International).

### **COMPUTATIONAL WORKSHOP IN LINEAR AND NONLINEAR STRUCTURAL AND SOLID MECHANICS**

Dates: July 27-31, 1981

Place: Schenectady, New York

Objective: For those interested in applications to current technological problems such as earthquake analysis, pipe whip dynamics and fluid-solid interaction, as well as other areas. The following will be covered: structural dynamics techniques for both linear and nonlinear many-degree-of-freedom systems; incremental loading into the plastic range and finite element methods in fracture mechanics; random vibration methods; response spectrum methods for many-degree-of-freedom systems. A nonlinear dynamics computer program as well as eigenvalue and sinusoidal analysis programs will be available for workshop use. Relative merits of ANSYS, SAP, ADINA, etc., programs will be discussed. Computer graphics for input generation and output presentation will be available.

Contact: Union College, Graduate Studies and Continuing Education, Wells House - 1 Union Ave., Schenectady, New York 12308 - (518) 370-6288.

### **COMPUTER WORKSHOP IN FINITE ELEMENT METHODS OF ANALYSIS FOR STRESS AND OTHER FIELD PROBLEMS**

Dates: July 27-31, 1981

Place: Schenectady, New York

Objective: For those interested in applications to current technological problems such as thermal and stress analysis of nuclear vessel nozzle, 3D pipe intersection, turbine blade application, water mass of nuclear fuel channels, as well as other areas. The following will be covered: finite element techniques for 2D and 3D structural analysis and dynamics, both 2D and 3D programs, including listings, generalization of finite element methods to heat transfer and

fluid flow with programs in each discipline; incremental loading into the plastic range and finite element methods in fracture mechanics; relative merits of ANSYS, SAP, ADINA, etc., programs. Computer graphics for input generation and output presentation will be available.

Contact: Union College, Graduate Studies and Continuing Education, Wells House - 1 Union Ave., Schenectady, New York 12308 - (518) 370-6288.

## **AUGUST**

### **MACHINERY DATA ACQUISITION**

Dates: August 3-7, 1981

September 28 - October 2, 1981

December 7-11, 1981

Place: Carson City, Nevada

Objective: This seminar is designed for people whose function is to acquire machinery data for dynamic analysis, using specialized instrumentation, and/or that person responsible for interpreting and analyzing the data for the purpose of corrective action on machines. Topics include measurement and analysis parameters, basic instrumentation review, data collection and reduction techniques, fundamental rotor behavior, explanation and symptoms of common machinery malfunctions, including demonstrations and case histories. The week also includes a lab workshop day with hands-on operation of the instrumentation and demonstration units by the participants.

Contact: Kathy Fredekind, Bently-Nevada Corporation, P.O. Box 157, Minden, Nevada 89423 - (702) 782-3611, Ext. 224.

### **RELIABILITY AND LIFE TESTING**

Dates: August 10-14, 1981

Place: University of California - Los Angeles

Objective: To cover the following subjects: Methodologies to improve the reliability of components, equipment and systems, follow their reliability growth, identify the distributions of their times-to-failure, determine their mean life, their reliability, and their failure rate, with their confidence limits at specified confidence levels, various new small-sample-size, short-duration reliability and life tests non-

parametric reliability and life tests; sequential tests for the exponential and binomial cases; tests of comparison for the exponential, Weibull and binomial cases; accelerated life testing; Bayesian life and reliability testing; identification of the appropriate times-to-failure distributions to use and the application of goodness-of-fit tests to distributions fitted to data; probability plotting techniques to find the parameters of the appropriate distributions to use.

Contact: Mr. Robert Rector, Assistant Director - Short Courses, UCLA, 6266 Boelter Hall, Los Angeles, CA 90024 - (213) 825-3496/1295/3344.

#### **FOUNDATIONS OF ENGINEERING ACOUSTICS**

Dates: August 10-21, 1981

Place: Cambridge, Massachusetts

Objective: This summer program is a specially developed course of study which is based on two regular MIT subjects (one graduate level and one undergraduate level) on vibration and sound in the Mechanical Engineering Department. The program emphasizes those parts of acoustics - the vibration of resonators, properties of waves in structures and air - the generation of sound and its propagation that are important in a variety of fields of application. The mathematical procedures that have been found useful in developing the desired equations and their solutions, and the processing of data are also studied. These include complex notation, Fourier analysis, separation of variables, the use of special functions, and spectral and correlation analysis.

Contact: Director of Summer Session, Room E19-356, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139.

#### **PYROTECHNICS AND EXPLOSIVES**

Dates: August 17-21, 1981

Place: Philadelphia, Pennsylvania

Objective: The seminar combines the highlights of Pyrotechnics and Solid State Chemistry, given the last twelve summers, and Explosives and Explosive Devices that made its successful appearance ten years ago. Similar to previous courses, the seminar will be practical so as to serve those working in the field. Presentation of the theory is restricted to that necessary for an understanding of basic principles and successful application to the field. Coverage empha-

sizes recent effort, student problems, new techniques, and applications.

Contact: Mr. E.E. Hannum, Registrar, The Franklin Research Center, Philadelphia, Pennsylvania 19103 - (215) 448-1236/1395.

#### **VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION**

Dates: August 24-28, 1981

Place: Santa Barbara, California

Dates: October 5-9, 1981

Place: Bournemouth, England

Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos St., Santa Barbara, CA 93105 - (815) 682-7171.

#### **MECHANICAL ENGINEERING**

Dates: August 31 - September 4, 1981

Place: Carson City, Nevada

Objective: This course is designed for the mechanical or maintenance engineer who has responsibility for the proper operation and analysis of rotating machinery. Working knowledge of transducers, data acquisition instrumentation and fundamental rotor behavior is a prerequisite. The course includes: a guest speaker in the field of machinery malfunctions; descriptions and demonstrations of machinery malfunctions; discussions of the classification, identification, and correction of various machine malfunctions; a one day rotor dynamics lab with individual instruction and operation of demonstration units; and emphasis on the practical solution of machinery problems rather than rotor dynamic theory.

Contact: Kathy Fredekind, Bently-Nevada Corporation, P.O. Box 157, Minden, Nevada 89423 - (702) 782-3611, Ext. 224.

## SEPTEMBER

### 10TH ADVANCED NOISE AND VIBRATION COURSE

Dates: September 14-18, 1981

Place: Southampton, England

Objective: The course is aimed at researchers and development engineers in industry and research establishments, and people in other spheres who are associated with noise and vibration problems. The course, which is designed to refresh and cover the latest theories and techniques, initially deals with fundamentals and common ground and then offers a choice of specialist topics. The course comprises over thirty lectures, including the basic subjects of acoustics, random processes, vibration theory, subjective response and aerodynamic noise, which form the central core of the course. In addition, several specialist applied topics are offered, including aircraft noise, road traffic noise, industrial machinery noise, diesel engine noise, process plant noise and environmental noise and planning.

Contact: Mrs. O.G. Hyde, ISVR Conference Secretary, The University, Southampton SO9 5NH, England - (0703) 559122 X 2310/752, Telex 47661.

### BASIC INSTRUMENTATION SEMINAR

Dates: September 15-17, 1981

Place: New Orleans, Louisiana

Dates: October 20-22, 1981

Place: Houston, Texas

Dates: October 27-29, 1981

Place: Pittsburgh, Pennsylvania

Objective: This course is designed for maintenance technicians, instrument engineers, and operations personnel - those individuals responsible for installation and proper operation of continuous monitoring systems. An in-depth examination of probe installation techniques and monitoring systems including types, functions, and calibration procedures is provided. Also presented is an overview of some of the

instrumentation used to acquire data for vibration analysis, including oscilloscopes, cameras, and specialized filter instruments.

Contact: Kathy Fredekind, Bently-Nevada Corporation, P.O. Box 157, Minden, Nevada 89423 - (702) 782-3611, Ext. 224.

## OCTOBER

### DESIGN OF FIXED OFFSHORE PLATFORMS

Dates: October 5-16, 1981

Place: Austin, Texas

Objective: This course is dedicated to the professional development of those engineers, scientists, and technologists who are and will be designing fixed offshore platforms to function in the ocean environment from the present into the twenty-first century. The overall objective is to provide participants with an understanding of the design and construction of fixed platforms, specifically the theory and processes of such design and the use of current, applicable engineering methods.

Contact: Continuing Engineering Studies, College of Engineering, Ernest Cockrell Hall 2.102, The University of Texas at Austin, Austin, Texas 78712 - (512) 471-3506.

### VIBRATION CONTROL

Dates: October 12-16, 1981

Place: University Park, Pennsylvania

Objective: The seminar emphasizes principles, general approaches and new developments, with the aim of providing participants with efficient tools for dealing with their own practical vibration problems.

Contact: Debra A. Noyes, 410 Keller Conference Center, University Park, Pennsylvania 16802 - (814) 865-8820, TWX No: 510-670-3532.

# NEWS BRIEFS:

news on current  
and Future Shock and  
Vibration activities and events

## SAE AEROSPACE CONGRESS AND EXPOSITION

Anaheim, California

October 5-8, 1981

The 1981 SAE Aerospace Congress and Exposition will be held October 5-8, 1981 at the Anaheim Convention Center, Anaheim, California.

The following is the preliminary program for session titled "Advances in Dynamic Testing and Analysis" to be presented by SAE Technical Committee G-5 on Monday, October 5, 1981:

Chairman: Dr. Robert Coppolino, The Aerospace Corporation  
Asst. Chairman: Rush E. Allen, National Technical Services

- ***Finite Element Acoustic/Structural Dynamic Analysis of Complex Systems***  
Dr. Robert Coppolino and Judy Peach, The Aerospace Corporation
- ***Methods of Reducing Fuel Slosh in Rectangular Tanks (Analysis and Experimental Correlation)***  
Bruce A. Rommel, Douglas Aircraft, McDonnell Douglas
- ***Structural Dynamic Modifications - An Extension to Model Analysis***  
Dave Formenti and Sri Welaratna, Structural Measurement Systems
- ***Structural Mode Sensitivity to Local Modifications***  
Dr. Robert Coppolino, The Aerospace Corporation
- ***Wave Force Identification for Offshore Structures***  
Stepan Simonian and David Rozelle, J.H. Wiggins Co.

Chairman: John R. Fowler, Hughes Aircraft Co.  
Asst. Chairman: Dr. Robert E. Holman, Hughes Aircraft Co.

- ***Single Point Excitation for Determination of Modal Characteristics of Shuttle Panels***  
Ralph Brillhart, Structural Dynamics Research Corp.
- ***Modal Parameter Estimation by a Simultaneous Ensemble Frequency Domain Method***  
Dr. Robert Coppolino, The Aerospace Corporation
- ***Robotics in Space***  
Dr. C. Thomas Savell, Structural Dynamics Research Corp.
- ***Analytical/Experimental Research for Active Control of Space Structures***  
Dr. Richard Stroud, Synergistic Technology, Inc.
- ***Structural Uncertainty in Dynamic Analysis***  
Dr. T.K. Hasselman, J.H. Wiggins Co.
- ***System Identification of Large-Scale Structures***  
Dr. Michael Dobbs, William Gundy and Kenneth D. Blakely, ANCO Engineers, Inc.

For further information, please contact: Roy W. Mustain, Rockwell Space Systems Group, AB 97, 12214 S. Lakewood Blvd., Downey, CA 90241.

# INFORMATION RESOURCES

## METALS AND CERAMICS INFORMATION CENTER

The Metals and Ceramics Information Center (MCIC) is the continuation of an uninterrupted program that started as the Titanium Metallurgy Laboratory in 1955 and evolved into the Defense Metals Information Center (DMIC). In 1971, DMIC and the Defense Ceramics Information Center (DCIC) were combined to form MCIC - the largest of the Department of Defense (DoD) Information Analysis Centers. Utilizing the research staff of Battelle's Columbus Laboratories, MCIC is able to provide a wide and in-depth range of technical products and services to all sectors of the DoD, other government agencies, their contractors, and the general industrial and academic communities in this country.

MCIC's objective is the collection, evaluation, and dissemination of timely information on the characteristics and utilization of advanced metals and ceramics of primary interest to DoD missions. MCIC scope essentially covers the following:

### METALS

- Titanium
- Aluminum and magnesium
- Beryllium
- Refractory metals
- High-strength steels
- Superalloys

### CERAMICS

- Borides
- Carbides
- Carbon/graphite
- Nitrides
- Oxides
- Sulfides and silicides
- Selected glasses and glass-ceramics

### PROCESSES

- Basic materials production
- Primary fabrication (forging, casting, rolling, extrusion, etc.)

- Secondary fabrication (metal removal, forming, etc.)
- Joining
- Powder processes
- Surface treatment
- Quality control and inspection

### PROPERTIES, APPLICATIONS, TESTING

- Environmental effects/corrosion
- Mechanical and physical properties
- Materials applications
- Test methods
- Sources/suppliers
- Specifications
- Design characteristics

The current MCIC data base of over 130,000 indexed and abstracted technical documents is maintained by the addition of new information from the continual scanning of government reports and the worldwide open technical literature. The knowledge of scientists and engineers throughout the Battelle staff is also utilized to assure a timely and authoritative technical information base from which MCIC's services and products can be derived. Since 1975, abstracted information has been entered on the Defense Technical Information Center's Defense RDT&E On-Line System (DROLS). The approximately 60,000 MCIC references in this system are now available to anyone having a DROLS terminal.

Using this data base and Battelle support, the Center is able to provide the following principle services

- Technical advice and assistance
- Summaries of important developments in materials technology
- State-of-the-art reports and handbooks
- Access to over 130,000 analyzed and indexed reference sources

Inquiries, such as requests for literature searches or a request for particular information on a specific

materials problem, are handled by MCIC staff in a timely manner. Responses can vary from a direct answer (over the telephone or by correspondence) to an annotated bibliography or plant visit by a Battelle technical staff member.

In certain highly specialized cases, the information and resources of MCIC are utilized to provide timely responses to unique needs of our users. Among the special studies undertaken are

- In-depth review and analysis of technical literature in highly specified areas
- Comparisons of foreign and domestic technologies
- Technical assistance in materials applications
- Review of materials standards/specifications
- Development of computer-based information systems and data banks
- Technical conference/symposia organization, administration, and publication of proceedings

Two specific examples of current special studies that should be noted are:

- Operation of the Carbon-Carbon Data Base. This limited-access data base provides up-to-date information on the use and performance of carbon-carbon composites in various rocket and space application.
- Publication of the U.S. Army ManTech Journal. This quarterly publication is an important part of technology transfer. The Journal provides a rapid review of the latest Army-sponsored manufacturing technology developments in many areas of technology.

A Current Awareness Bulletin (CAB) is issued monthly to summarize significant developments in technology related to

- Light Metals
- High-Strength Steels

- Superalloys
- Refractory Metals
- Ceramics
- Selected Glasses and Glass Ceramics
- Carbon/Graphite
- Coatings
- Processing
- Fabrication
- Properties (physical/mechanical)
- Environmental Effects
- Test Methods

The emphasis in the technical section of the CAB is placed on DoD-related technical developments. In addition, pertinent new items are included covering technical meetings, R&D contract awards, and new technical literature.

Each year MCIC publishes a variety of engineering handbooks, databooks, and state-of-the-art reports on topics of important concern in the utilization of advanced metals and ceramics. Authors are selected from the Battelle staff, industry, and government to provide the latest and most authoritative engineering information on a variety of technical topics.

It is a DoD requirement that a fee be paid for MCIC products and services. In cases where this is required, fees are quoted in advance and are based on incurred costs only.

Further information regarding the products and services of MCIC can be obtained by contacting:

Mr. Harold Mindlin, Program Manager  
Metals and Ceramics Information Center  
Battelle's Columbus Laboratories  
505 King Avenue  
Columbus, Ohio 43201

General Inquiries: 614-424-5000  
Technical Inquiries: 614-424-6376

# ABSTRACT CATEGORIES

## MECHANICAL SYSTEMS

Rotating Machines  
Reciprocating Machines  
Power Transmission Systems  
Metal Working and Forming  
Isolation and Absorption  
Electromechanical Systems  
Optical Systems  
Materials Handling Equipment

Blades  
Bearings  
Belts  
Gears  
Clutches  
Couplings  
Fasteners  
Linkages  
Valves  
Seals  
Cams

Vibration Excitation  
Thermal Excitation

## STRUCTURAL SYSTEMS

Bridges  
Buildings  
Towers  
Foundations  
Underground Structures  
Harbors and Dams  
Roads and Tracks  
Construction Equipment  
Pressure Vessels  
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Structural Components  
Strings and Ropes  
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Beams  
Cylinders  
Columns  
Frames and Arches  
Membranes, Films, and Webs  
Panels  
Plates  
Shells  
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Pipes and Tubes  
Ducts  
Building Components

## MECHANICAL PROPERTIES

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Fatigue  
Elasticity and Plasticity

## VEHICLE SYSTEMS

Ground Vehicles  
Ships  
Aircraft  
Missiles and Spacecraft

## ELECTRIC COMPONENTS

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Scaling and Modeling  
Diagnostics  
Balancing  
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Modeling Techniques  
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## DYNAMIC ENVIRONMENT

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Acoustic Excitation  
Shock Excitation

## GENERAL TOPICS

Conference Proceedings  
Tutorials and Reviews  
Criteria, Standards, and  
Specifications  
Bibliographies  
Useful Applications

# ABSTRACTS FROM THE CURRENT LITERATURE

Copies of articles abstracted in the DIGEST are not available from the SVIC or the Vibration Institute (except those generated by either organization). Inquiries should be directed to library resources. Government reports can be obtained from the National Technical Information Service, Springfield, VA 22151, by citing the AD-, PB-, or N- number. Doctoral dissertations are available from University Microfilms (UM), 313 N. Fir St., Ann Arbor, MI; U.S. Patents from the Commissioner of Patents, Washington, D.C. 20231. Addresses following the authors' names in the citation refer only to the first author. The list of periodicals scanned by this journal is printed in issues 1, 6, and 12.

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# MECHANICAL SYSTEMS

## ROTATING MACHINES

(Also see Nos. 1225, 1247, 1258, 1354, 1361, 1365, 1366, 1367, 1369, 1370, 1394, 1400, 1401, 1402)

### 81-1168

#### **Coupled Torsional-Flexural Vibration of a Shaft in a Geared System of Rotors (1st Report)**

H. Iida, A. Tamura, K. Kikuchi, and H. Agata  
Tokyo Inst. of Tech., Ookayama, Meguro-ku, Tokyo, Japan, Bull. JSME, 23 (186), pp 2111-2117 (Dec 1980) 12 figs, 6 refs

**Key Words:** Shafts (machine elements), Rotors, Gear couplings, Spur gears, Coupled response, Torsional vibration, Flexural vibration

Coupled torsional-flexural vibrations of a shaft in a spur geared system are investigated. Equations of motion which contain the terms of geometrical eccentricity of gears and mass unbalance are introduced. The coupling between torsional and flexural displacements is considered in the equations which assume that surfaces of tooth of meshed gears are always in contact during the rotation. By solving the equations, it is possible to get natural frequencies, mode shapes, and frequency response of the system. Comparing the results with uncoupled theory reveals some new phenomena. They are: shifts of the critical speeds, transformations of the mode shapes, and a forced vibration which is caused by geometrical eccentricity of a gear.

### 81-1169

#### **Stress Concentration in a Torsionally Loaded Shaft with a Suddenly Varying Boundary**

R. Brepta  
Faculty of Technical and Nuclear Physics, Czech Technical Univ., Prague, Czechoslovakia, *Strojnický Časopis*, 31 (6), pp 695-706 (1980) 10 figs, 10 refs (In Czech)

**Key Words:** Shafts (machine elements), Torsional excitation

This paper deals with the analytical solution of dynamical stress concentration in the vicinity of a sudden change of the shaft boundary which is loaded by a non-stationary torsional stress wave. The conditions for the existence of

stress concentration and the type of stress singularity are developed. The applied method of solution allows the study of the stress concentration in rotating bodies with a sudden change of boundaries in cases of dynamic torsional loading.

### 81-1170

#### **Problem of Rotor Passing through Critical Speed with Gyroscopic Effect (3rd Report, Case of Rotating Shaft on Flexible Supports)**

K. Nonami and M. Miyashita  
Faculty of Engrg., Tokyo Metropolitan Univ., Setagaya-ku, Tokyo, Japan, Bull. JSME, 23 (186), pp 2104-2110 (Dec 1980) 12 figs, 10 refs

**Key Words:** Rotors, Critical speeds, Flexible rotors, Shafts (machine elements)

This paper reports the nonstationary vibration of a rotating shaft on flexible supports passing through critical speed. In particular the interaction or the coupling effect caused near critical speeds in continuous passing through 1st and 2nd critical speeds has been studied. For the case of a rotor system on damped flexible supports, its approximate equation in transition through the critical speed has been derived by an asymptotic method. Moreover, observing nonstationary maximum amplitudes, the analytical results have been considered. The experiments support the analysis.

### 81-1171

#### **Heat Propagation Due to Torsional Vibration of Shafts**

S. Panteliou and A. Dimarogonas  
Machine Design Lab., Univ. of Patras, Patras, Greece, J. Sound Vib., 73 (2), pp 239-245 (Nov 22, 1980) 4 figs, 10 refs

**Key Words:** Shafts (machine elements), Torsional vibration, Material damping, Heat generation

Torsional vibration of rotating shafts can yield substantial temperatures in the shaft due to heat generated from material damping. It has been recently observed that such a situation in electric generators can lead to insulation failures and machine outages. In the study reported here forced torsional vibration is assumed, and both lumped mass and continuous systems are considered. The hysteretic model for material damping is used to yield the heat generation in the elastic deformation range and an elastoplastic material is assumed in the plastic range. The heat conduction equation is solved for a cylindrical shaft with surface cooling.

**Closed form solutions and expressions for the maximum temperatures and the maximum surface temperatures are obtained and tabulated for design purposes. It is shown that substantial temperatures can develop in shafts undergoing torsional vibration.**

Deutsch Forschungs- und Versuchsanstalt fur Luft- und Raumfahrt e.V., Institut fur Turbulenzforschung, Berlin, Germany, J. Sound Vib., 73 (2), pp 297-308 (Nov 22, 1980) 8 figs, 1 table, 23 refs

### **81-1172**

#### **Determination of the Limit of Initiation of Self-Excited Vibration of Rotors**

**A. Tondl**

National Res. Inst. for Machine Design, Praha 5, Czechoslovakia, Intl. J. Nonlin. Mechanics, 15 (4/5), pp 417-428 (1980) 13 figs, 1 table, 5 refs

**Key Words:** Rotors, Self-excited vibration

A method is described of determining the limit frequencies of initiation of self-excited vibration of rotor systems for every vibration mode, or the limit frequencies of rotor rotation corresponding to a particular amplitude for single-frequency vibration of different modes, as a function of a specified system parameter. The method enables the optimum value of this parameter to be determined directly.

**Key Words:** Turbomachinery noise, Fans, Blowers, Compressors, Noise reduction, Acoustic resonators

A method by which an acoustic resonator can be used to reduce at source the aerodynamic noise generated by turbomachinery has been investigated experimentally. The casing of a small, centrifugal blower was modified by replacing the cut-off of the scroll with the mouth of a quarter-wavelength resonator. The mouth of the resonator was constructed from a series of perforated plates with the same curvature as the cut-off to preserve the original geometry of the casing. Tuning of the resonator was achieved by changing the length via a movable end plug. The noise measurements were made in an anechoically terminated outlet duct at nearly a free delivery operating condition of the blower. With appropriate tuning of the resonator, reductions in the blade passing frequency tones of up to 29 dB were observed with corresponding overall sound pressure level reductions of up to 7dB(A). Parameters which influenced the band width of the resonator response were the porosity and hole size of the resonator mouth and the flow velocity near the cut-off region. Throughout the tests, the aerodynamic performance of the blower was unaffected by the addition of the resonator to the casing.

### **81-1173**

#### **Regions of Instability of Motion of a Disc Supported by an Asymmetric Flexible Shaft in Asymmetric Bearings**

**T. Kotera**

Kobe Univ., Rokko-dai 1, Nada-ku, Kobe 657, Japan, Strojnický Časopis, 31 (5), pp 553-565 (1980) 6 figs, 4 refs

**Key Words:** Discs, Shafts (machine elements), Flexible rotors, Rotors, Variable material properties, Asymmetry

In the present paper a method for determining regions of instability of a system with periodically variable coefficients almost exactly is presented. A disc supported by an asymmetric flexible shaft in asymmetric bearings is considered.

### **81-1175**

#### **Analysis and Correlation of Test Data from an Advanced Technology Rotor System**

**D. Jepson, R. Moffitt, and J.B. Hilzinger**

Sikorsky Aircraft, Stratford, CT, Rept. No. NASA-CR-152366, SER-510034, 169 pp (July 1980) N80-33351

**Key Words:** Rotors, Helicopters, Rotary wings, Vibration measurement, Wind tunnel tests

The performance and blade vibratory loads characteristics for an advanced rotor system as predicted by analysis and as measured in a 1/5 scale model wind tunnel test are reported. A full scale model wind tunnel test and flight test were compared.

### **81-1174**

#### **Reduction of Centrifugal Fan Noise by Use of Resonators**

**W. Neise and G.H. Koopmann**

### **81-1176**

#### **Comparison of Calculated and Measured Helicopter Rotor Lateral Flapping Angles**

**W. Johnson**

NASA Ames Res. Ctr., Moffett Field, CA, Rept. No. NASA-TM-81213, AVRADCOM-TR-80-A-11, 27 pp (July 1980)  
N80-33349

**Key Words:** Rotors, Helicopters, Wind tunnel tests, Vortex-induced vibration

Calculated and measured values of helicopter rotor flapping angles in forward flight are compared for a model rotor in a wind tunnel and an autogiro in gliding flight. The lateral flapping angles can be accurately predicted when a calculation of the nonuniform wake-induced velocity is used. At low advance ratios, it is also necessary to use a free wake geometry calculation. For the cases considered, the tip vortices in the rotor wake remain very close to the tip-path plane, so the calculated values of the flapping motion are sensitive to the fine details of the wake structure, specifically the viscous core radius of the tip vortices.

Inst. for Higher Education, Limerick, Eire, J. Sound Vib., 73 (2), pp 211-223 (Nov 22, 1980) 11 figs, 16 refs

**Key Words:** Disks (shapes), Thermal excitation, Variable cross section, Natural frequencies, Flexural vibration

Details and results are presented of an experimental analysis of the natural frequencies of free transverse vibration of two annular discs subjected to the combined action of centrifugal and thermal stressing. One disc is of constant thickness form, whilst the other is of linearly varying thickness form. The results obtained experimentally are subsequently compared with those as predicted by a finite element technique previously described by the first two authors. In general the comparisons are found to be favorable, when account is taken of the sources of error in the experimental analysis.

#### **81-1177**

#### **Helicopter Rotor Head Mounting Assembly**

R.C. Rybicki

Dept. of the Army, Washington, D.C., Rept. No. AD-D007 743/8, PAT-APPL-869 185, 5 pp (Nov 1979)

PATENT-4 175 913

**Key Words:** Helicopters, Rotors, Mountings

A helicopter rotor head mounting assembly includes a rotor drive shaft and a rotor hub splined to the shaft for rotation therewith. The rotor hub includes a central bore having an internal tapered portion which is forced downwardly upon a mating tapered portion of the rotor drive shaft. An annular split cone is mounted between the rotor shaft and the hub at a bottom portion of the hub bore and the split cone is forced upwardly into firm engagement with the hub and drive shaft by means of a plurality of individual loading means which are carried by an annular plate affixed to the bottom of the hub. The loading means are individually adjustable and apply loading force directly onto the split cone to thereby assure a secure, non-vibrational rotation of the hub with the rotor shaft.

#### **81-1179**

#### **Aspects of Noise in Rotary Vacuum Pumps**

J.K.N. Sharma and P.K. Dutta

National Physical Lab., New Delhi, 110012, India, Appl. Acoust., 13 (6), pp 425-432 (Nov/Dec 1980) 6 figs, 1 table, 5 refs

**Key Words:** Pumps, Rotary pumps, Noise generation, Spectrum analysis

In this paper the authors describe a detailed spectral analysis of noise in a rotary vacuum pump. The noise sample studied could help to identify various noise sources in different frequency regions. The importance of correct balancing/machining of the rotor and the stator and the optimization of the oil flow rate are also stressed. The quantitative data thus obtained are indicative of trends in the design of modern rotary vane vacuum pumps.

#### **81-1180**

#### **Probabilistic Analysis of Foundation Forces for a Class of Unbalanced Rotating Machines**

L. Boyce

Ph.D. Thesis, Texas A&M Univ., 105 pp (1980)  
UM 8101577

**Key Words:** Rotors, Foundations, Unbalanced mass response, Probability theory

This dissertation considers the problem of the foundation force of an unbalanced rotating machine from both deterministic and probabilistic viewpoints.

## RECIPROCATING MACHINES

(See No. 1397)

## POWER TRANSMISSION SYSTEMS

**81-1181**

### How to Design Quiet Transmissions

R.J. Drago

Boeing Vertol Co., Philadelphia, PA, Mach. Des., 52 (28), pp 175-181 (Dec 11, 1980) 12 figs

**Key Words:** Power transmission systems, Gears, Shafts (machine elements), Bearings, Housings, Noise control, Design techniques

Although silencing measures can be applied to a transmission after it is designed and built, the initial engineering of a product should include as many noise-reduction measures as possible. Gears, shafts, bearings, and housings all have an important effect on acoustical output, and their noise characteristics can be largely controlled at the drawing board.

## METAL WORKING AND FORMING

(Also see Nos. 1238, 1400, 1401, 1402)

**81-1182**

### Dynamic Cutting Coefficients in Three-Dimensional Cutting

V. Grasso, S.N. La Diega, and A. Passannanti

Istituto di Tecnologie Meccaniche, Facolta di Ingegneria, Viale delle Scienze, 90128 Palermo, Italy, Intl. J. Mach. Tool Des. Res., 20 (3/4), pp 235-249 (1980) 10 figs, 10 refs

**Key Words:** Machine tools, Chatter, Cutting

A new theory to predict the dynamic cutting coefficients from steady state cutting data is developed. The derived expressions are able to take into account the effect of the main angles defining the tool geometry on the chatter stability limit and show a good agreement with experimental results. The proposed model allows the identification of a parameter as an index for chatter sensitivity of the work material.

## ELECTROMECHANICAL SYSTEMS

**81-1183**

### Adaptive Mechanisms (Automatic Vibration Control)

B. Sandler

Dept. of Mech. Engrg., Ben Gurion Univ. of the Negev, Beersheva, Israel, J. Sound Vib., 73 (2), pp 161-175 (Nov 22, 1980) 17 figs, 7 refs

**Key Words:** Automatic control, Vibration control, Mechanisms

This paper deals with the problem of automatic control of vibrations in mechanisms by the use of self-adjustable structures. Three levels of complexity are discussed and corresponding experiments are described. The paper compares some approaches which provide adaptive behavior of a 4 mass self-adjustable vibrating device. Linear modeling, identification and physical measuring techniques are described.

## MATERIALS HANDLING EQUIPMENT

**81-1184**

### Noise of Crank, Cam and Stepping Mechanisms (Lärm von Kurbel-, Kurven- und Schrittgetrieben)

V. Kunzel

VEB Textimaforschung Malimo Karl-Marx-Stadt, Maschinenbautechnik, 30 (1), pp 21-23 (Jan 1981) 7 figs, 8 refs  
(In German)

**Key Words:** Textile looms, Noise reduction

Noise generating drive parameters of textile machinery were investigated and presented. Noise reduction techniques are proposed, tested, and the levels of reduction are discussed.

## STRUCTURAL SYSTEMS

## BRIDGES

**81-1185**

### Fatigue of Curved Steel Bridge Elements - Ultimate Strength Tests of Horizontally Cued Plate and Box Girders

J.H. Daniels, T.A. Fisher, R.P. Batcheler, and J.K. Maurer  
Fritz Engrg. Lab., Lehigh Univ., Bethlehem, PA,  
Rept. No. FEL-398.7, FHWA-RD-79-137, 86 pp  
(Aug 1979)  
PB81-116923

**Key Words:** Bridges, Steel, Girders, Plate girders, Box girders, Fatigue tests

This report presents the results of the ultimate strength tests of one curved non-composite plate girder assembly, two curved composite plate girder assemblies and two curved composite box girders. The primary objectives of the research reported herein are: to determine the load-deflection behavior of large size curved plate girder assemblies and curved box girders which are loaded to ultimate strength, and to compare the experimental behavior with analytic predictions. This study is of very limited scope and is intended only as a pilot study of the ultimate strength of curved plate and box girders.

#### 81-1186

#### **Fatigue of Curved Steel Bridge Elements: Design Recommendations for Fatigue of Curved Plate Girder and Box Girder Bridges**

J.H. Daniels, J.W. Fisher, and B.T. Yen  
Fritz Engrg. Lab., Lehigh Univ., Bethlehem, PA,  
Rept. No. FEL-398.8, FHWA/RD-79-138, 64 pp  
(Apr 1980)  
PB81-115115

**Key Words:** Bridges, Steel, Girders, Plate girders, Box girders, Fatigue life, Specifications

Research on the fatigue behavior of horizontally curved, steel bridge elements was conducted. The multi-phase investigation spanning nearly five years was performed in five tasks: analysis and design of five large scale horizontally curved steel twin plate girder assemblies and three large scale horizontally curved steel box girders, primarily for fatigue testing; special analytical studies of the influences on fatigue of stress range gradient, heat curving, oil canning of webs and the spacing of internal diaphragms in curved box girders; fatigue tests, to 2,000,000 cycles, of each of the above eight curved test girders; ultimate strength tests of three of the curved plate girder assemblies and two of the curved box girders following the fatigue tests (composite reinforced concrete slabs were added to two of the three curved plate girder assemblies and to both curved box girders); and development of design recommendations suitable for inclusion in the AASHTO bridge design Specifications.

#### 81-1187

#### **Fatigue of Curved Steel Bridge Elements - Effect of Internal Diaphragms on Fatigue Strength of Curved Box Girders**

J.H. Daniels, D. Abraham, and B.T. Yen  
Fritz Engrg. Lab., Lehigh Univ., Bethlehem, PA,  
Rept. No. FEL-398.6, FHWA-RD-79-136, 60 pp  
(Aug 1979)  
PB81-116915

**Key Words:** Bridges, Steel, Girders, Diaphragm couplings, Box girders, Fatigue life

The investigation is centered on the effect of welded details on curved girder fatigue strength. Fatigue tests of five full-scale curved plate girder assemblies and three full-scale curved plate girder assemblies and three full-scale curved box girders are part of the investigation. This report examines analytically the effects of spacing of rigid interior diaphragms on the stresses and deflections of curved box girders. Available computer programs are employed and existing results are utilized with little emphasis on the procedure of computation. The objective is to assess the qualitative relationship between stresses and the coupling influence of diaphragm spacing and curvature, so as to gain insight to the fatigue behavior of box girders.

#### 81-1188

#### **Fatigue of Curved Steel Bridge Elements - Effect of Heat Curving on the Fatigue Strength of Plate Girders**

J.H. Daniels and R.P. Batcheler  
Fritz Engrg. Lab., Lehigh Univ., Bethlehem, PA,  
Rept. No. FEL-398.5, FHWA-RD-79-135, 69 pp  
(Aug 1979)  
PB81-116907

**Key Words:** Bridges, Steel, Plate girders, Thermal effects, Fatigue life

This multiphase investigation involves the performance of five tasks: analysis and design of large scale test assemblies; special studies of selected topics; fatigue tests and ultimate load tests of test assemblies; and development of design recommendations. This report presents the results of a special study of the effects of heat curving on the fatigue strength of plate girders.

#### 81-1189

#### **Fatigue of Curved Steel Bridge Elements - Analysis and Design of Plate Girder and Box Girder Test Assemblies**

J.H. Daniels, N. Zettlemoyer, D. Abraham, and R.P. Batcheler  
Fritz Engrg. Lab., Lehigh Univ., Bethlehem, PA,  
Rept. No. FEL-398.1, FHW-RD-79-131, 112 pp  
(Aug 1979)  
PB81-116899

**Key Words:** Bridges, Steel, Girders, Plate girders, Box girders, Fatigue tests

This multi-phase investigation involves the performance of five tasks: analysis and design of large scale plate girder and box girder test assemblies; special studies of selected topics; fatigue tests of the curved plate girder and box girder test assemblies; ultimate load tests of the test assemblies; and development of design recommendations suitable for inclusion in the AASHTO design specifications. The first task, analysis and design of horizontally curved plate girder and box girder test assemblies, is contained herein. The research effort centered on fatigue crack propagation at welded details.

**Key Words:** Bridges, Suspension bridges, Cable stiffened structures, Wind-induced excitation

This paper outlines the application of the theory of stochastic dynamics to evaluate the forced response of suspension bridges subjected to gusty winds. The main emphasis is placed on the analysis of the along-wind response and complete formulae for the root-mean-square response are worked out. The concept of gust response factors is also discussed. The effects of lateral cables as a means to reduce the along-wind response are considered. Numerical results of four suspension bridges with center spans in the range 525-1250 m are presented, including a discussion of the general trend of the along-wind response.

## BUILDINGS

(Also see Nos. 1255, 1318, 1398, 1399)

### 81-1190

#### **Dynamic Analysis of Bridge Tower-Pier Systems by Substructure Method**

T. Balendra

Dept. of Civil Engrg., National Univ. of Singapore, Singapore, Intl. J. Mech. Sci., 22 (12), pp 721-730 (1980) 5 figs, 3 tables, 17 refs

**Key Words:** Bridges, Towers, Piers, Substructuring methods, Time domain method

A tower-pier system is analyzed in the time domain by reducing the governing equations to two coupled integro-differential equations in terms of the interaction displacements. The formulation facilitates to discard the insignificant modes of the tower.

### 81-1192

#### **Overall Safety Assessment of Multistory Steel Buildings Subjected to Earthquake Loads. Evaluation of Seismic Safety of Buildings**

S.P. Lai

Dept. of Civil Engrg., Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. R80-26, NSF/RA-800204, 285 pp (June 1980)

PB81-111718

**Key Words:** Buildings, Steel, Earthquake damage

A set of 140 earthquake records were used to assess the uncertainties involved in ground motion representation. In particular, seismic input was characterized in terms of the Kanai-Tajimi power spectral density function and the strong-motion duration. Based on the method of spectral moments, key Kanai-Tajimi parameters were determined for the set of records. The statistics and interdependences of these parameters were evaluated. The correlation between these K-T parameters, strong-motion duration, peak ground acceleration, epicentral distance and local magnitude was investigated. Based on an extensive simulation study, semi-empirical modifications were made to an existing random vibration solution for single-degree-of-freedom elasto-plastic systems. Similar modifications were incorporated in an approximate multi-degree-of-freedom elasto-plastic random vibration methodology for shear-beam systems, and its validity was assessed by a series of compatibility studies. By using the random vibration methodology, the overall inelastic seismic safety analysis of buildings was formulated.

### 81-1191

#### **Along-Wind Response of Suspension Bridges with Special Reference to Stiffening by Horizontal Cables**

R. Sigbjornsson and E. Hjorth-Hansen

Foundation of Scientific and Indus. Res. at the Norwegian Inst. of Tech., Trondheim, Norway, Engrg. Struc., 3 (1), pp 27-37 (Jan 1981) 14 figs, 3 tables, 15 refs

**81-1193****Dynamic Behavior of LLNL Buildings During Aftershocks of the January 24, 1980 Greenville Earthquake**

Lawrence Livermore Lab., California Univ., Livermore, CA, 18 pp (Apr 1980)  
UCRL-52969

**Key Words:** Computer programs, Buildings, Seismic response, Mode shapes, Natural frequencies, Damping coefficients

Computer programs developed at the Lawrence Livermore National Laboratory (LLNL) were used to extract information about the dynamic behavior of several LLNL structures from velocity time-history signals recorded during two earthquake aftershocks. The most complete analysis was performed on Building 111. This analysis is presented as a case study to show the power of the LLNL computer codes in identifying the principal vibratory modes of a structure and the frequencies and damping values of these modes. The importance of this technique for monitoring changes in the seismic integrity of critical structures is discussed.

**81-1194****Study of X-Braced Steel Frame Structures under Earthquake Simulation**

Y. Ghanaat  
Ph.D. Thesis, Univ. of California, Berkeley, 226 pp (1980)  
UM 8029401

**Key Words:** Buildings, Framed structures, Braces, Steel, Earthquake simulation

Analytical techniques employing three different hysteresis models to represent the three types of bracing systems are shown to predict the response of braced frames with excellent accuracy. The mathematical model of the rod braces simulated both tension yielding and elastic buckling with tension rod rupture mechanism included; pipe and double angle bracing members included both tension yielding and post-buckling behavior; residual elongation and reduction of compressive capacity with the number of cycles was considered in the double angle model. Analytical response predictions for the unbraced frame, employing concentrated bilinear plastic hinges for all members including joint connections, also are shown to be very accurate for the levels of nonlinearity encountered. The results of this study indicate that diagonal bracing systems such as pipe and double angle braces are very effective in reducing lateral displacements of buildings for moderate earthquakes and that their energy dissipation will be significant if their compressive capacity is not less than 50 percent of their tension capacity.

**81-1195****The Structural Fuse: An Inelastic Approach to Seismic Design of Buildings**

M. Fintel and S.K. Ghosh

Advanced Engrg. Services, Portland Cement Assn., Skokie, IL, Civ. Engrg. (NY), 51 (1), pp 48-51 (Jan 1981) 4 figs, 4 refs

**Key Words:** Buildings, Seismic design, Energy dissipation, Concrete construction, Steel

A new approach to earthquake-resistant building design depends on making some structural members weaker to dissipate earthquake energy, protecting more crucial members - in effect, the weaker members serve as "structural fuses." The technique is applicable to concrete and steel design and is now being implemented in structures in the U.S. and Canada.

**81-1196****Evaluation of Noise from Air-Conditioning Systems - A Draft Proposal**

M. Filippi and R. Pompoli

Istituto di Fisica Tecnica e Impianti Nucleari, Politecnico, Corso Duca degli Abruzzi No. 24, Turin, Italy, Appl. Acoust., 13 (6), pp 433-440 (Nov/Dec 1980) 6 figs, 1 table, 3 refs

**Key Words:** Buildings, Air conditioning equipment, Noise generation, Sound pressure levels

This paper discusses the practical evaluation of noise levels generated by air-conditioning and ventilating systems inside buildings. The results of this work are incorporated in a Draft Italian Standard. The criterion for evaluation is based on the difference between the total sound pressure level in the room when the noise source is working, and the background noise level. The allowable difference must decrease with the value of the background noise level. The measured sound pressure level is corrected according to the type of noise and to the acoustical characteristics of the room; impulsive noises should not be present in the system.

**TOWERS**

(See No. 1190)

**FOUNDATIONS**

(Also see Nos. 1180, 1246)

**81-1197****Influence of Shear and Compression Interaction on the Response of Sand to Dynamic Loading**

P.M. Griffin

Ph.D. Thesis, Univ. of California, Berkeley, 517 pp  
(1980)  
UM 8029412

**Key Words:** Sand, Dynamic tests, Resonant column tests,  
Hollow cylinder tests, Shakers

An experimental research program based on laboratory test studies and scaled slope model tests was conducted with specimens of Monterey No. 0 sand. The principal objective of the research was to study the effects of interactive coupling during combined compression (normal) and shear loading on the response of sands to dynamic loading. The research program included the following experimental studies: resonant column tests on cylindrically shaped specimens using longitudinal and torsional excitation, both separately and in combination; thin-walled hollow cylinder tests using longitudinal and torsional cyclic excitation, both separately and in combination; and large scale shaking table tests on slope models, using horizontal and vertical cyclic excitation, both separately and in combination.

**81-1199**

**Nonlinear Analysis of Light Water Reactor (LWR) Components: Areas of Investigation/Benefits/Recommendations**

S.J. Brown

O'Donnell and Associates, Inc., Pittsburgh, PA, Rept. No. OD-1350-2-79, 210 pp (Apr 1980)  
ALO-76/1

**Key Words:** Nuclear reactor components, Nonlinear theories, Design techniques, Testing techniques

The purpose of this study is to identify specific topics of investigation into design procedures, design concepts, methods of analysis, testing practices, and standards which are characterized by nonlinear behavior (both geometric and material) and which are considered to offer some economic and/or technical benefits to the LWR industry (excluding piping). In this study these topics were collected, compiled, and subjectively evaluated as to their potential benefit. The topics considered to have the greatest benefit/impact potential are discussed.

## **HARBORS AND DAMS**

(See No. 1363)

## **POWER PLANTS**

(Also see Nos. 1353, 1368)

**81-1198**

**Critical Excitation Method for Calculating Earthquake Effects on Nuclear Plant Structures: An Assessment Study**

B. Bedrosian, M. Barbela, R.F. Drenick, and A. Tsirk  
Burns and Roe, Inc., Oradell, NJ, 145 pp (Oct 1980)  
NUREG/CR-1673

**Key Words:** Nuclear power plants, Earthquake damage, Seismic analysis, Critical excitation method

The critical excitation method provides a new, alternative approach to methods presently used for seismic analysis of nuclear power plant structures. The critical excitation method offers the advantages that: it side-steps the assumptions regarding the probability distribution of ground motions; and it does not require an artificial, and to some extent arbitrarily generated, time history of ground motion, both features to which structural integrity analyses are sensitive. Potential utility of the critical excitation method is studied from the user's viewpoint. The method is reviewed and compared with the response spectrum method used in current practice, utilizing the reactor buildings of a PWR and a BWR plant in case studies.

**81-1200**

**Flow-Induced Vibration Analysis of Nuclear Components**

M.J. Pettigrew

Chalk River Nuclear Labs., Atomic Energy of Canada Ltd., Chalk River, Ontario, Canada, Rept. No. CONF-7806125-11, 48 pp (Aug 1978)  
AECL-6219

**Key Words:** Nuclear reactor components, Fluid-induced excitation, Fatigue life, Wind-induced excitation, Damping

Excessive flow-induced vibration may lead to fretting-wear or fatigue problems in nuclear components. Some recent vibration problems and their solution are reviewed. The analytical and experimental techniques used to solve or preferably avoid flow-induced vibration problems are emphasized in this paper. Vibration excitation mechanisms in parallel and cross-flow and in both liquid and two-phase steam-water flow will be discussed. These vibration excitation mechanisms and the structural dynamics of nuclear components are formulated in analytical models. This is illustrated by the application of a computer model to analyze steam generator designs. Current studies related to flow-induced vibration are reviewed. Among these are: the in-reactor vibration behavior of nuclear fuel elements; the prediction of vibration-fretting damage for heat exchanger tube materials; and the damping of wind-induced vibration of heavy water plant structures.

### 81-1201

#### An Exploration of the Design for a PCCV Head Slab with Very Large Penetrations Using a Dynamic Relaxation Computer Program

C.C. Fleischer, P.L.T. Morgan, and B.R. Waine

Taylor Woodrow Construction Ltd., Southall, Middlesex, UK, Nucl. Engng. Des., 61 (1), pp 79-92 (Nov 1980) 9 figs, 1 table, 4 refs

**Key Words:** Nuclear reactor containment, Prestressed concrete, Dynamic relaxation, Computer programs

A prestressed concrete containment vessel for a Liquid Metal Fast Breeder Reactor has been developed. The current design for the head slab for this vessel differs geometrically from previous head slabs for other reactors. This head slab has a single very large central penetration which is surrounded by an annulus in which there are a number of large and small penetrations. The total area taken by penetrations is in excess of 50% of the total pressurized plan area. This paper describes a computer analysis carried out using a dynamic relaxation code to assess the structural behavior of the head slab. The effects of variations in the geometry and boundary conditions have been examined. The mathematical models considered were based on one of a series of small scale physical models intended to validate the design of the containment structure. Comparison between the experimental model results and those of the theoretical analyses indicate general agreement in crack patterns and failure modes. However, there are some discrepancies in actual failure pressures.

Measurements of the noise from a General Electric C36-7 diesel electric locomotive were performed with the locomotive stationary and attached to a load cell during powered and unpowered pass-by tests.

### 81-1203

#### Analysis and Measurement of Locomotive Dynamic Characteristics

P. Tong, R. Brantman, and R. Greif

Transportation Systems Ctr., Cambridge, MA, ASME Paper No. 79-WA/RT-10

**Key Words:** Locomotives, Interaction: rail-vehicle

In June of 1977, comparative tests of the E-8 and SDP-40F locomotives were conducted on Chessie System track with the goal of comparing dynamic performance of these locomotives and identifying key track, vehicle, and operational parameters affecting safety. Based on the test results, it was possible to establish that significant differences existed in the response of these two locomotives when operating in curves above the balance speed. The test data also enabled quantification of the influence of variations in truck vertical damping, lateral axle clearance, and wheel diameter mismatch.

### 81-1204

#### Motorcycle Acceleration Noise in the Urban Setting

G.W. Kamperman

S/V, Sound Vib., 14 (12), pp 6-7 (Dec 1980) 5 figs, 2 tables

**Key Words:** Motorcycles, Noise measurement, Urban noise, Field test data

Motorcycle acceleration noise tests were conducted at seven different test sites. For this study the concept of the 0 to 100 ft, 5 second acceleration test was adopted. Maximum noise level measurements were made off to the side of the vehicle path at distances of 15 ft, 25 ft and 50 ft. All motorcycle noise testing was conducted on large flat asphalt surfaces with the microphones positioned 4 ft above the asphalt surface. It was found that contemporary motorcycles and passenger cars accelerating at the same rate produce the same maximum noise level.

## VEHICLE SYSTEMS

### GROUND VEHICLES

(Also see Nos. 1232, 1233, 1249, 1251, 1278, 1313, 1314, 1355)

### 81-1202

#### Measurement and Diagnosis of the Noise from a General Electric C36-7 Diesel Electric Locomotive

N.R. Dixon

Bolt, Beranek and Newman, Inc., Cambridge, MA, Rept. No. BBN-4167, DOT-TSC-FRA-79-26, FRA/ORD-69/52, 105 pp (Dec 1979)

PB81-112914

**Key Words:** Locomotives, Interaction: rail-wheel, Noise generation, Noise measurement

### 81-1205

#### The Influence of Structural Flexibilities on the Straight-running Stability of Motorcycles

R.S. Sharp and C.J. Alstead

Dept. Mech. Engrg., Univ. of Leeds, Vehicle Syst. Dyn., 9 (6), pp 327-357 (Dec 1980) 14 figs, 1 table, 22 refs

**Key Words:** Motorcycles, Tire characteristics, Natural frequencies, Modal damping, Torsional response, Lateral response

A new tire model for studies of motorcycle lateral dynamics, and three new motorcycle models, each incorporating a different form of structural compliance, are developed. The tire model is based on "taut string" ideas, and includes consideration of tread width and longitudinal tread rubber distortion and tread mass effects, and normal load variation. Parameter values appropriate to a typical motorcycle tire are employed. The motorcycle models are for small lateral perturbations from straight running at constant speed, and include lateral compliance of the front wheel in the front forks, torsional compliance of the front forks, and torsional compliance in the rear frame at the steering head about an axis perpendicular to the steering axis. Results in the form of eigenvalues, indicating modal damping properties and natural frequencies are presented for each model. The properties of four large production machines for a range of forward speeds, and the practicable range of stiffnesses are calculated, and the implications are discussed.

#### 81-1206

#### **A Computer Model to Predict Traffic Noise in Urban Situations under Free Flow and Traffic Light Conditions**

L.J.M. Jacobs, L. Nijs, and J.J. van Willigenburg Inst. for Town Planning Res., Delft Univ. of Tech., The Netherlands, J. Sound Vib., 72 (4), pp 523-537 (Oct 22, 1980) 10 figs, 3 tables, 29 refs

**Key Words:** Mathematical models, Traffic noise, Noise prediction, Urban noise

A computer model is presented for predicting traffic noise indices in built-in situations for free flow traffic conditions and for a flow interrupted by a traffic light. The stream of vehicles is simulated by a given time headway distribution, and a transfer function obtained from a 1:100 scale model is used to simulate the specific built-up situation.

#### 81-1207

#### **Noise Reduction Retrofit for a 'New Look' Flexible Transit Bus: Service Bulletin**

M.C. Kaye

Tri-County Metropolitan Transportation District of Oregon, Portland, OR, Rept. No. DOT-TSC-UMTA-80-16, UMTA-OR-06-005-80-1, 66 pp (Sept 1980) PB80-226103

**Key Words:** Traffic noise, Buses, Noise reduction

This document presents instructions on how to apply a noise treatment to a contemporary city transit bus without extensive structural alteration. Baseline bus configuration, noise ratings, and performance benchmarks are presented for a Flexible 111DC-D061 transit bus powered by a Detroit Diesel 8V-71N engine. The concepts and much of the hardware described in this report are transferable to similar buses.

#### 81-1208

#### **Computer-Aided Evaluation of Dynamic Loads on Ground Vehicles -- Using Drive Elements of a Tractor as an Example (Rechnergestützte Auswertung dynamischer Belastungsverläufe an Fahrzeugen -- am Beispiel der Antriebselemente eines Ackerschleppers)**

R.H. Biller and W. Paul

Institut f. Betriebstechnik der Bundesforschungssanstalt f. Landwirtschaft, Germany, Konstruktion, 33 (1), pp 29-33 (Jan 1981) 6 figs, 10 refs  
(In German)

**Key Words:** Ground vehicles, Tractors, Dynamic excitation, Computer-aided techniques

A procedure for sizing structural elements based on operational loads is presented. The operational loads are presented as a plot of the log of relative cumulative frequency against the load cycle. Using the results from an actual experiment, a classification program is presented which allows simultaneous evaluation of forces on a computer.

#### 81-1209

#### **Modal Analysis Applications in Vehicle Development**

G. Dodlacher and I. Rericha  
Fasanenweg 4, 5024 Pulheim, Automobiltech. Z., 82 (11), pp 589-592 (Nov 1980)  
(In German)

**Key Words:** Ground vehicles, Vibration analysis, Modal analysis, Testing techniques, Test equipment and instrumentation

In recent years the modal analysis became a useful tool in vehicle development with regard to vibration analysis. The application of modal analysis, the test equipment and the test procedure in vehicle development at Ford-Köln are described. Practical examples are given and the mode shapes are shown.

## SHIPS

### 81-1210

#### Potential Hydroelastic Instability of Profiled Underwater Structures

L.E. Ericsson and J.P. Reding

Lockheed Missiles & Space Co., Inc., Sunnyvale, CA, J. Hydronautics, 14 (4), pp 97-104 (Oct 1980) 16 figs, 17 refs

**Key Words:** Underwater structures, Cantilever beams, Hydrodynamic excitation, Self-excited vibrations

Appendages on underwater vehicles are often given a cross-sectional profile that will produce low drag. The potential danger is that if the profile shape is not selected carefully, the structural integrity of the appendage may be endangered by hydroelastic instability. While static divergence is usually investigated, the potential for divergent oscillations leading to destructive amplitudes is not recognized as readily. Structural damping, which often is a saving feature for wind-induced loads, plays a completely insignificant role in a high-density fluid such as water. The unsteady hydrodynamic characteristics leading to self-excited oscillations are derived analytically and the means by which the dynamic instability can be minimized or eliminated are described.

## AIRCRAFT

(Also see Nos. 1176, 1177, 1348, 1369, 1370, 1371, 1388, 1389, 1390, 1392)

### 81-1211

#### Diagnostic Evaluation of Jet Noise Suppression Mechanisms

P.R. Giesebe

General Electric Co., Cincinnati, OH, J. Aircraft, 17 (12), pp 837-842 (Dec 1980) 14 figs, 10 refs

**Key Words:** Aircraft noise, Jet noise, Noise reduction

A unified aeroacoustic jet noise prediction method has been developed based on the modeling of principal noise genera-

tion and emission mechanisms from first principles. It is demonstrated herein that this jet noise prediction method is a useful diagnostic tool for assessing the relative importance of the various mechanisms for a given nozzle type. The relative contributions of turbulent mixing noise suppression, shock-cell broadband noise suppression, convective amplification suppression, and fluid shielding attenuation have been evaluated for a high element number multichute suppressor to arrive at a plausible explanation for how multi-element suppressors suppress jet noise. This explanation, an alternative view to historical conceptions of jet noise suppression, suggests an approach to designing low noise suppressor nozzles.

### 81-1212

#### Predicted Airframe Noise Levels

J.P. Raney

Langley Res. Ctr., National Aeronautics and Space Admn., Hampton, VA, Rept. No. NASA-TM-81849, 10 pp (Sept 1980) N80-34218

**Key Words:** Aircraft noise, Noise prediction

Calculated values of airframe noise levels corresponding to FAA noise certification conditions for six aircraft are presented. The aircraft are: DC-9-30; Boeing 727-200; A300-B2 Airbus; Lockheed L-1011; DC-10-10; and Boeing 747-200B. The prediction methodology employed is described and discussed.

### 81-1213

#### Evaluation of AERO Commander Sidewall Vibration and Interior Acoustic Data: Static Operations

A.G. Piersol, E.G. Wilby, and J.F. Wilby

Bolt, Beranek and Newman, Inc., Canoga Park, CA, Rept. No. NASA-CR-159290, BBN-4016, 92 pp (Oct 1980) N80-33392

**Key Words:** Aircraft, Aircraft vibration, Interior noise

Results for the vibration measured at five locations on the fuselage structure during static operations are presented. The analysis was concerned with the magnitude of the vibration and the relative phase between different locations, the frequency response (inertance) functions between the exterior pressure field and the vibration, and the coherent output power functions at interior microphone locations based on sidewall vibration.

**81-1214****Study of Lateral Excess Sound Attenuation as Determined from Far Part 36 Aircraft Noise Certification Measurements**

D.E. Bishop and J.M. Beckman

Bolt, Beranek and Newman, Inc., Canoga Park, CA,  
Rept. No. BBN-4225, AFAMRL-TR-80-65, 58 pp  
(July 1980)

AD-A088 285/2

**Key Words:** Aircraft noise, Noise measurement, Sound attenuation

This report presents information on the variation of the lateral excess attenuation as a function of elevation angle. Lateral excess attenuation represents the differences between the noise levels measured directly underneath the aircraft and to the side of the aircraft, after adjustment for differences in distance and air absorption. The study shows that useful excess attenuation information can be developed from aircraft certification data provided steps are taken to locate sideline positions so that measurements adequately cover the range of low elevation angles. The measured excess attenuation values show trends with frequency that are consistent with measurements observed in recent Air Force tests in the frequency range up to about 400 Hz.

**81-1215****Washington National Airport Flight Extension Test. Noise Monitoring Data Report**

J.R. Hare, Jr. and D.W. Ford

Office of Environment and Energy, Federal Aviation Admin., Washington, D.C., Rept. No. FAA/EE-80-25, 102 pp (May 1980)

AD-A089 111/9

**Key Words:** Aircraft noise, Noise measurement

This report summarizes noise measurements obtained during the Washington National Airport Flight Extension Test conducted during the summer of 1979. During this test, south departing turbojet aircraft were directed to fly over the Potomac River corridor an additional five miles prior to being directed toward their destinations. Monitoring sites were set up in the affected areas to determine the effect of the change in operations on the ambient noise levels. Equivalent noise levels (L<sub>eq</sub>) were obtained on an hourly basis and averaged for each site. The results show no statistically significant change in averaged equivalent noise levels at three sites. Significant decreases in L<sub>eq</sub> were recorded at four sites and five of the twelve sites observed some statistically significant increase in equivalent sound levels. Maximum levels (dBA) were also recorded for single aircraft events.

**81-1216****Experiments on the Validity of Ground Effect Predictions for Static Noise Testing of Propeller Aircraft**

G.J.J. Ruijgrok

Delft Univ. of Tech., Dept. of Aerospace Engrg.,  
Delft, The Netherlands, J. Sound Vib., 72 (4), pp  
469-479 (Oct 22, 1980) 8 figs, 16 refs**Key Words:** Aircraft noise, Noise prediction

The practical importance of an advanced ground effect theory for the prediction of free field noise spectra from static field measurements above grassland is investigated. Empirical noise data from a ground-based light propeller aircraft are compared with predictions. The results show that short range propagation of low frequency noise is adequately described by theory. It is also shown, however, that at intermediate and high frequencies detailed experiments on ground interference effects remain required to determine the characteristics of the noise source.

**81-1217****Airframe Noise Reduction Studies and Clean Airframe Noise Investigation (Final Report)**

M.R. Fink and D.A. Bailey

United Technologies Res. Ctr., East Hartford, CT,  
Rept. No. NASA-CR-159311; R80-914626-12, 84 pp  
(Apr 1980)  
N80-33175**Key Words:** Airframes, Noise reduction, Aircraft wings, Wind tunnel tests, Geometric effects

Acoustic wind tunnel tests were conducted on a wing model with modified leading edge slot and trailing edge flap. The modifications were intended to reduce the surface pressure response to convected turbulence and thereby reduce the airframe noise without changing the lift at constant incidence.

**81-1218****Response of Nonlinear Panels to Random Loads**

C. Mei

Old Dominion Univ., Norfolk, VA, Langley Res. Ctr.,  
Res. in Nonlinear Struct. and Solid Mech., pp 141-163 (1980)  
N80-32766

**Key Words:** Panels, Aircraft, Acoustic excitation, Fatigue life, Sonic fatigue resistant structures

Lightweight aircraft structures exposed to a high intensity noise environment can fatigue prematurely if adequate consideration is not given to the problem. Design methods and design criteria for sonic fatigue prevention were developed based on analytical and experimental techniques. Most of the analytical work was based upon small deflection or linear structural theory which did not agree with the experimental results. A large deflection geometrical nonlinearity was incorporated into the analysis methods for determining the structural response to high intensity noise. Comparisons with experimental results are presented.

are represented by source distributions. The mutual interference between the bodies is accounted for by use of images, and the flow tangency conditions on the planar surfaces are then satisfied at several control points on the wings and fins. Corrections for aspect ratio and wing-tail interference were applied. The predictions were found to agree well with other analytical solutions and with wind tunnel results.

### **81-1219**

#### **Prediction of Structural Fatigue Response under Aircraft Loads from Material Stress-Strain Behavior**

A. Berkovits

Dept. of Aeronautical Engrg., Technion - Israel Inst. of Tech., Haifa, Israel, Israel J. Tech., 17 (5/6), pp 347-353 (1979) 8 figs, 15 refs

**Key Words:** Aircraft, Fatigue life, Crack propagation, Finite element technique

A finite element program was developed for estimating fatigue behavior of notched structures based on properties of unnotched material. Fatigue crack initiation life, crack propagation rate, and fatigue failure were determined in terms of applied load spectrum. Fatigue response can be predicted for load spectra typical of aircraft.

### **81-1221**

#### **Relationship of Unsteadiness in Downwash to the Quality of Parameter Estimates**

W.R. Wells and D.A. Keskar

Wright State Univ., Dayton, OH, J. Aircraft, 17 (12), pp 905-908 (Dec 1980) 5 figs, 4 tables, 9 refs

**Key Words:** Aircraft, Aerodynamic characteristics, Parameter identification technique

This paper investigates the relative importance of including unsteady effects in the lift and downwash in the longitudinal dynamics and parameter extraction algorithm. A simple vortex system has been used to model unsteady incompressible aerodynamic effects into the longitudinal equations of motion of an aircraft. Computer-generated data and flight data were used to demonstrate that inclusion of unsteady aerodynamics in the parameter-extraction algorithm produced aerodynamic parameters that were different from those extracted when unsteady aerodynamics were left out of the algorithm. The differences between derivatives associated with the two extraction algorithms (with and without unsteady aerodynamics) were related to acceleration derivatives which usually cannot be extracted individually.

### **81-1220**

#### **A Method for Calculating the Aerodynamic Forces and Moments on External Stores of Aircraft**

T. Ronen and M. Hanin

Dept. of Aeronautical Engrg., Technion - Israel Inst. of Tech., Haifa, Israel, Israel J. Tech., 17 (5/6), pp 295-301 (1979) 10 figs, 11 refs

**Key Words:** Aircraft, Wing stores, Aerodynamic loads

This paper presents a method for predicting the aerodynamic forces and moments on external stores near aircraft, assuming potential incompressible flow. The flow due to angle of attack is calculated using slender wing and body assumptions: the bodies are represented by doublets and the wings by a set of vortex panels, each panel having constant vorticity per unit length. Thickness effects of the bodies and the wings

### **81-1222**

#### **Aircraft Crash Survival Design Guide, Volume IV. Aircraft Seats, Restraints, Litters, and Padding**

S.P. Desjardins and D.H. Laananen

Simula Inc., Tempe, AZ, Rept. No. TR-7822, USAR-TL-TR-79-22D, 276 pp (June 1980) AD-A088 441/1

**Key Words:** Crash research (aircraft), Crashworthiness, Aircraft seats, Safety restraint systems, Aircraft seat belts, Energy absorption

This five-volume document has been assembled to assist design engineers with the development of crashworthy U.S. Army aircraft. The five volumes of the Aircraft Crash Survival Design Guide cover the following topics: Volume I - Design Criteria and Checklists; Volume II - Aircraft Crash

**Environment and Human Tolerance; Volume III - Aircraft Structural Crashworthiness; Volume IV - Aircraft Seats, Restraints, Litters, and Padding; Volume V - Aircraft Post-crash Survival.** This volume (Volume IV) contains information on aircraft seats, litters, personnel restraint systems, and hazards in the occupant's immediate environment. Requirements for design of seats, litters, and restraint systems are discussed, as well as design principles for meeting these requirements and testing for verification that the systems perform as desired. Energy-absorbing devices for use in seat are described, as are various types of cushions. Delethalization of cockpit and cabin interiors is discussed, including the use of protective padding and the design of controls for prevention of injury. Finally, computerized methods of analysis for evaluation of seats, restraints, and the occupant's immediate environment are presented.

St. Louis, MO, SAE Paper No. 801193, 16 pp, 16 figs, 11 refs

**Key Words:** Aircraft, Hydraulic equipment, Computer programs, Dynamic structural analysis

Four complementary digital computer programs have been developed, verified, and documented for the design and dynamic analysis of aircraft hydraulic systems. These programs model typical hydraulic system components and use a building block technique to permit modeling of systems or subsystems with varying degrees of complexity. This paper briefly describes the four computer programs and presents case histories of specific computer program applications.

#### **81-1223**

#### **Aircraft Crash Survival Design Guide, Volume III, Aircraft Structural Crashworthiness**

D.H. Laananen, G.T. Singley, III, A.E. Tanner, and J.W. Turnbow  
Simula Inc., Tempe, AZ, Rept. No. TR-7821, USAR-TL-TR-79-22C-VOL-3, 273 pp (Aug 1980)  
AD-A089 104/4

**Key Words:** Crash research (aircraft), Crashworthiness

This five-volume document has been assembled to assist design engineers in understanding the problems associated with the development of crashworthy U.S. Army aircraft. It includes not only a collection of available information and data pertinent to aircraft crashworthiness but suggested design conditions and criteria as well. Volume III contains information on the design of aircraft structures and structural elements for improved crash survivability. Current requirements for structural design of U.S. Army aircraft pertaining to crashworthiness are discussed. Principles for crashworthy design are presented in detail for the landing gear and fuselage subject to a range of crash conditions, including impacts that are primarily longitudinal, vertical, or lateral in nature and those that involve more complicated dynamic conditions, such as rollover. Analytical methods for evaluating structural crashworthiness are described.

#### **81-1225**

#### **Transonic Rotor Noise - Theoretical and Experimental Comparisons**

F.H. Schmitz and Y.H. Yu  
Aeromechanics Lab., Army Res. and Tech. Labs., Moffett Field, CA, 29 pp (1980);  
AD-A090 806/1

**Key Words:** Helicopters, Rotors, Noise generation

Two complementary methods of describing the high-speed rotor noise problem are discussed. Good agreement between theoretical and experiments' waveforms is shown for transonic hover tip Mach numbers.

#### **81-1226**

#### **A Comprehensive Analytical Model of Rotorcraft Aerodynamics and Dynamics. Part 1. Analysis Development**

W. Johnson  
Ames Res. Ctr., NASA, Moffett Field, CA, Rept. No. NASA-A-8100, NASA-TM-81182-PT-1, 442 pp (June 1980)  
AD-A090 513/3

**Key Words:** Helicopters, Rotors, Aerodynamic loads, Helicopter noise, Helicopter vibration, Wind-induced excitation, Mathematical models

The development of a comprehensive analytical model of rotorcraft aerodynamics and dynamics is presented. This analysis is designed to calculate rotor performance, loads, and noise; helicopter vibration and gust response; flight

#### **81-1224**

#### **Digital Computer Simulation of Aircraft Hydraulic Systems**

R.J. Levek  
McDonnell Aircraft Co., McDonnell Douglas Corp.,

dynamics and handling qualities; and system aeroelastic stability. The analysis is a combination of structural, inertial, and aerodynamic models that is applicable to a wide range of problems and a wide class of vehicles. The analysis is intended for use in the design, testing, and evaluation of rotors and rotorcraft, and to be a basis for further development of rotary wing theories. The analysis is implemented in a digital computer program.

#### 81-1229

#### On the Use of Active Higher Harmonic Blade Pitch Control for Helicopter Vibration Reduction

C.E. Hammond and J.E. Cline

Structures Lab., Army Res. and Tech. Labs., Hampton, VA, 17 pp (June 1980)

AD-A090 398/9

**Key Words:** Blades, Rotary wings, Helicopters, Rotors, Vibration control

Vibration levels have been a problem in helicopters since their inception. The reason for this lies in the method whereby the helicopter generates its lift, namely, the rotor system. As the rotor blades rotate they encounter a continuously changing aerodynamic environment which results in a continuously changing environment which results in a continuously changing aerodynamic loading on the blades. This changing environment is repeated on each revolution of the rotor. Hence, the rotor develops aerodynamic loads which are oscillatory in nature. These oscillatory loads are transferred directly to the helicopter airframe through the mechanical connection of the rotor to the airframe, i.e., the rotor-shaft/transmission attachment. Oscillatory loads are also transmitted to the airframe by impingement of the rotor wake on the upper portion of the airframe, but the mechanically transferred loads are in most cases much more significant than the aerodynamically transferred loads.

#### 81-1227

#### Landing Gear In-Flight Vibration Dampener

R.D. Leoni

Dept. of the Army, Washington, D.C., PAT-APPL-869 090, 4 pp (Oct 30, 1979)

PATENT-4 172 570

**Key Words:** Helicopters, Landing gear, Tuning

During flight, helicopter landing gears are suspended by a tuning spring from the helicopter airframe to provide limited relative movement between the landing gear masses and the airframe. As the aircraft vibrates due to vertical or in-plane forces at the rotor head, the landing gear masses react oppositely thereto, thus generating balancing forces which are applied to the airframe to balance the rotor excitations.

### MISSILES AND SPACECRAFT

(Also see Nos. 1400, 1401, 1402)

#### 81-1228

#### An Evaluation of a Computer Code Based on Linear Acoustic Theory for Predicting Helicopter Main Rotor Noise

S.J. Davis and T.A. Egolf

Sikorsky Aircraft, Stratford, CT, Rept. No. NASA-CR-159339, SER-510038, 290 pp (July 1980)  
N80-34217

**Key Words:** Computer programs, Helicopter noise, Helicopters, Rotors, Time domain method, Noise prediction

Acoustic characteristics predicted using a recently developed computer code were correlated with measured acoustic data for two helicopter rotors. The analysis is based on a solution of the Ffowcs-Williams-Hawkins (FW-H) equation and includes terms accounting for both the thickness and loading components of the rotational noise. Computations are carried out in the time domain and assume free field conditions.

#### 81-1230

#### Mated Vertical Ground Vibration Test

E.W. Ivey

NASA, Marshall Space Flight Ctr., Huntsville, AL, Rept. No. NASA-TM-78298, 96 pp (July 1980)  
N80-32425

**Key Words:** Space shuttles, Vibration tests

The Mated Vertical Ground Vibration Test (MVGVT) was considered to provide an experimental base in the form of structural dynamic characteristics for the shuttle vehicle. This data base was used in developing high confidence analytical models for the prediction and design of loads, pogo controls, and flutter criteria under various payloads and operational missions. The MVGVT boost and launch program evolution, test configurations, and their suspensions are described. Test results are compared with predicted analytical results.

# BIOLOGICAL SYSTEMS

## HUMAN

(Also see Nos. 1183, 1267)

**81-1231**

### **A Modified PNdB for Assessment of Low Frequency Noise**

N. Broner and H.G. Leventhall

Dept. of Physics, Chelsea College, Univ. of London, London, SW6 5PR, UK, J. Sound Vib., 73 (2), pp 271-277 (Nov 22, 1980) 2 figs, 3 tables, 37 refs

**Key Words:** Human response, Noise tolerance, Low frequencies

As part of an investigation into the prediction of annoyance due to high level low frequency noise, the use of the Perceived Noise Level (PNL) in PNdB was considered. It was found that the PNL extended to include lower frequencies down to the  $25 \text{ Hz}^{\frac{1}{3}}$  octave band was superior to the standard PNL.

**81-1232**

### **Relationship between Truck Ride Quality and Safety of Operations: Methodology Development**

R.H. Klein, R.W. Allen, and J.C. Miller

Systems Technology, Inc., Hawthorne, CA, Rept. No. SRI-TR-1155-1, DOT-HS-805 494, 189 pp (June 1980)

PB80-224108

**Key Words:** Trucks, Vibration tolerance, Human response

This report presents an overall program plan, including sample experimental design, which can be used to determine the effects of vehicle vibration upon driver performance. The recommended solution is to combine a fixed-base driving simulator facility with a high-frequency motion base 'ride quality' facility. The result is an interactive 'ride simulator' that allows line drivers to perform real-world tasks while under very tightly controlled traffic and vibration scenarios.

**81-1233**

### **Community Noise Levels in Patras, Greece**

T.C. Stathis

Lab. of Appl. Thermodynamics, School of Engrg., Univ. of Patras, Patras, Greece, J. Acoust. Soc. Amer., 69 (2), pp 468-477 (Feb 1981) 6 figs, 7 tables, 16 refs

**Key Words:** Urban noise, Traffic noise, Human response, Noise tolerance

In the city of Patras (Greece), noise measurements were made for the purposes of determining the present noise-pollution levels and the reaction of the people to them. For the latter purpose, a social survey was conducted with the use of a relevant questionnaire which was applied to 500 citizens. Its results show that noise pollution is ranked second in order after air pollution, and that traffic was the principal noise pollutant.

# MECHANICAL COMPONENTS

## ABSORBERS AND ISOLATORS

(Also see No. 1183)

**81-1234**

### **Decoupling Approach to Modeling Perforated Tube Muffler Components**

K. Jayaraman and K. Yam

Dept. of Chemical Engrg., Michigan State Univ., East Lansing, MI 48824, J. Acoust. Soc. Amer., 69 (2), pp 390-396 (Feb 1981) 11 figs, 3 refs

**Key Words:** Mufflers, Tubes, Hole containing media, Ducts, Resonant frequencies

A transformation is derived to decouple the two differential equations describing one-dimensional acoustic wave propagation in the presence of mean flow, in mufflers with partitioned, perforated tubes. The following analysis leads to compact and exact expressions for the matrix parameters of crossflow elements without any concern for convergence of infinite series or segmental analysis employed in earlier studies. The present analysis is based on assumptions of a uniform perforate impedance on the tube, and of equal mean flow in the two ducts. The predicted transmission loss curves agree very well with published data.

**81-1235**

### **The Effect of Temperature upon Some Dynamic Properties of a Rubber Spring**

R. Chmurny, P. Tirinda, W. Oliferuk, I. Sitarek, and J. Wicher  
Institut of Machine Mechanics of the Slovak Academy of Sciences, Bratislava, Czechoslovakia, Strojnícky Časopis, 31 (6), pp 745-752 (1980) 6 figs, 5 refs  
(In Slovak)

**Key Words:** Springs (elastic), Thermal excitation, Vibration response

This contribution deals with some problems of the thermal dependence of the dynamic properties of a vibrating system with a rubber spring. Some results are presented that have been measured at diverse levels of harmonic load.

K. Ikeuchi and H. Mori  
Kyoto Univ., Kyoto, Japan, Bull. JSME, 23 (186), pp 2145-2151 (Dec 1980) 16 figs, 4 refs

**Key Words:** Bearings, Squeeze film bearings, Lubrication, Periodic excitation

A 2-dimensional periodic elastohydrodynamic squeeze film between a rigid plane and an elastomer of uniform thickness attached on a rigid substrate is theoretically analyzed. Time-dependent film shape and pressure distribution through each period are calculated about a 2-dimensional model, and an elastic periodic squeeze film with an incompressible lubricant is found to be able to keep hydrodynamic lubrication condition under positive load.

#### 81-1236

#### The Transient Behaviour of the Dynamic Vibration Absorber for Linear Frequency Rise

A. Ascari  
Istituto di Matematica dell'Università, Parma, Mecanica, 15 (2), pp 107-111 (June 1980) 1 fig, 3 refs

**Key Words:** Dynamic vibration absorption (equipment), Transient response

The applicability of the Frahm dynamic vibration absorber is generally restricted to the case of constant forcing frequency; it may happen, however, that this condition is fulfilled only after a certain instant, prior to which the frequency is increasing, e.g. linearly. The analysis of the transient behavior shows that in such a situation the main mass can undergo oscillations much broader than those predictable by the constant frequency scheme.

#### 81-1238

#### A System Approach to the Dynamic Characteristics of Hydrostatic Bearings Used on Machine Tools

K.N. Chen, G.P. Yang, X. Wang, and H.H. Yang  
Intl. J. Mach. Tool Des. Res., 20 (3/4), pp 287-297 (1980) 6 figs, 20 refs

**Key Words:** Hydrostatic bearings, Bearings, Machine tools, Systems approach, Impact response (mechanical)

The dynamic performance of the hydrostatic bearing system used on a grinding machine is analyzed on the basis of the closed loop control theory. A system block diagram and the corresponding transfer functions are depicted. The response of the system to an impulse impact load is recorded and processed on a digital computer using the curve fitting method. The paper shows that the system approach is a powerful tool for analysis and design of hydrostatic bearing systems used on machine tools.

### TIRES AND WHEELS

(See No. 1205)

### BLADES

(See No. 1229)

### BEARINGS

#### 81-1237

#### A Study on a Squeeze Film with a Compliant Plane under Periodic Motion

#### 81-1239

#### The Measurement of the Radial Stiffness of Rolling Element Bearings under Oscillating Conditions

T.L.H. Walford and B.J. Stone  
Ransome Hoffman Pollard Ltd., J. Mech. Engrg. Sci., 22 (4), pp 175-181 (Aug 1980) 10 figs, 5 refs

**Key Words:** Bearings, Roller bearings, Ball bearings, Stiffness coefficients

There is very little information available on the characteristics of rolling element bearings under oscillating conditions. This is because of the difficulty that has been experienced in measuring the relevant characteristics. A rig is described

which is very simple in principle and allows the measurement of the radial stiffness of a pair of bearings. For the angular contact bearings tested the levels of damping obtained are larger than previously expected.

## GEARS

(Also see No. 1168)

### 81-1240

#### Parametrically Excited Gear Vibrations (Parametrisch erregte Getriebebechwingungen)

H. Peeken, C. Troeder, and G. Diekhans

Aachen, VDI Z., Part 1: 122 (2), pp 869-877 (Oct 1980); Part 2: 122 (21), pp 967-977 (Nov 1980); Part 3: 122 (22), pp 1029-1043 (Nov 1980), 37 figs, 18 refs

**Key Words:** Gears, Parametric excitation, Helical gears, Clearance effects, Error analysis

The vibration of a single step gear is investigated taking into account parametric excitation of straight and helical gears, axial and flexural degrees of freedom, gear clearance, and gear errors. The results are obtained numerically by means of a mathematical model. The load increment function and the resonance amplitudes can be described by means of generally valid characteristic factors, so that these results can be applied also to other drives.

### 81-1241

#### Load Transmission and Power Branching in Spur Gear Systems with Positive Drive (Die Kraftübertragung und der Leistungsfluss in zwangsläufigen gleichförmig übersetzenden Getrieben)

K.H. Vatterott

Philips GmbH Apparatefabrik Wetzlar, Germany, Forsch. Ingenieurwesen, 46 (5), pp 167-171 (1980)

8 figs, 15 refs  
(In German)

**Key Words:** Gears, Spur gears

Power branching in gearwheel drives may be effective for constructive and/or economical reasons. It is also possible in power branching networks of general dimensions with positive drive. The degree of freedom equation is an aid for the analysis and synthesis of the various structures. A limitation of the geometric parameters results from the static

conditions with respect to the load equalization of the power branches. The basis of the calculations is formed by the laws of statics. With the aid of possible speed and acceleration parameters the dynamic additional forces can be worked out as in the example. Furthermore the influencing factors of the static and dynamic additional forces are characterized by the load equalization.

### 81-1242

#### Contribution to Optimizing the 2 x OHC TATRA

#### 613 Type Gear Mechanism

S. Žiaran

Dept. of Tech. Mechanics, Faculty of Mech. Engrg., Slovak Tech. Univ., Bratislava, Czechoslovakia, Strojnícky Časopis, 31 (6), pp 737-743 (1980) 6 figs, 5 refs

(In Slovak)

**Key Words:** Gears, Noise reduction, Optimization

The theoretical substantiation is given in the paper of the increased noise of a gear mechanism with its cam shaft revolving in the negative sense as against a gear mechanism whose cam shaft revolves in the positive sense. Such parameters are sought which lead to lowering its noise. A power analysis is made on a balance beam. This analysis is the starting point in setting up the object function. By optimizing the gear with the negative sense of revolution the transverse force producing transverse vibration and thus increasing noise, has been reduced by 34 per cent, thus making the gear more stable.

## COUPLINGS

(Also see No. 1168)

### 81-1243

#### Improve Coupling Selection through Torsional Vibration Modeling

H. Schwerdin and R. Eshleman

Lovejoy, Inc., Downers Grove, IL, Power Transmission Design, 23 (2), pp 56-59 (Feb 1981) 2 tables

**Key Words:** Couplings, Vibration analysis

For a proper selection of couplings, in addition to strength and misalignment tolerance data, torsional natural frequencies of the physical system are required. Ten simple formulas for the calculation of these frequencies are given, requiring two major physical quantities: stiffness and polar moment of inertia. Both can be obtained from vendor data, measurement, or calculation.

## FASTENERS

(Also see No. 1255)

81-1244

**The Application of the Cross Spring Joint for Improvement of Smooth Running in the Construction of Processing Machinery (Untersuchung des Kreuzfedergelenks im Hinblick auf seine Einsatzmöglichkeiten im Verarbeitungsmaschinenbau zur Laufuhverbesserung)**

F. Köhler and K. Butter

VEB Textilmeforschung Malimo Karl-Marx-Stadt, Maschinenbautechnik, 29 (10), pp 445-448 (Oct 1980) 12 figs, 2 tables, 4 refs

(In German)

**Key Words:** Joints (junctions), Noise reduction, Machinery noise, Design techniques

Approximation formulas for calculation of torsional rigidity, internal forces or flexural moments as well as the displacement of rotation axis of the cross spring joint are given. The dependence of these characteristics upon the geometry of the cross spring joint is theoretically studied by means of diagrams. The structural solution for the use of cross spring joints instead of needle bearings is shown at a textile machine.

non-linear equations are derived and approximate solutions are found by the Ritz-Galerkin method. A numerical example is given and the significance of the results is discussed with regard to the galloping oscillations of overhead transmission lines.

## BARS AND RODS

81-1246

**The Effect of an Arbitrarily Located Mass on the Longitudinal Vibrations of a Bar**

M.A. Cutchins

Dept. of Aerospace Engrg., Auburn Univ., Auburn, AL 36830, J. Sound Vib., 73 (2), pp 185-193 (Nov 22, 1980) 7 figs, 11 refs

**Key Words:** Bars, Mass-beam systems, Natural frequencies, Mode shapes, Axial vibration

For a bar/mass assembly the vibrational effect of the mass, assumed slender in comparison with the length dimension of the bar to which it is centrally attached, is investigated for various mass positions and various mass ratios. The investigation is limited to harmonic disturbances in line with the bar and symmetry of the mass with respect to the bar centerline. A general relationship for the ratio of the inertial force acting on the attached mass to the magnitude of a harmonic end force is developed. Some comparisons with experimental results are given which verify the derived closed form solutions.

## STRUCTURAL COMPONENTS

### CABLES

(Also see No. 1364)

81-1245

**On Non-Linear Free Vibrations of an Elastic Cable**

P. Hagedorn and B. Schafer

Institut f. Mechanik, TH Darmstadt, W. Germany, Intl. J. Nonlin. Mechanics, 15 (4/5), pp 333-340 (1980) 1 fig, 9 refs

**Key Words:** Cables (ropes), Free vibration, Ritz-Galerkin method, Transmission lines, Galloping

The effect of non-linear terms in the equations of motion on the first normal modes of the oscillations of an elastic flexible cable under the action of gravity is studied. The

### BEAMS

(Also see Nos. 1185, 1186, 1187, 1188, 1189, 1324, 1337, 1338)

81-1247

**The Normal Modes of Beam-Like Structures by a Lanczos-Stodola Method**

T. Niblett

Royal Aircraft Est., Farnborough, UK, Rept. No. RAE-TR-80058, DRIC-BR-74671, 15 pp (May 1980) AD-A088 169/8

**Key Words:** Beams, Rotors, Flexural vibration, Torsional vibration, Mode shapes

A method of finding the flexural and torsional normal modes of structures which have straight stiffness axes and which are

mounted as cantilevers is given. The Lanczos method of minimized iterations is used to obtain intermediate modes using the integro-differential equations and the mass and stiffness distributions. The dominant eigenvalues and vectors of the inertia matrix give good approximations to the graver normal bodies. Results of test calculations using a computer program which also allows for the presence of discrete masses are given.

tained by exploiting characteristic transcendental equations. The natural flexural vibrations of the beam are only affected by the stiffness of the supports over a very restricted range; outside this range the frequencies are those of a completely free beam or of a beam supported by two simple rigid supports (infinite stiffness).

#### 81-1248

#### On the Derivation of Equations of Motion for a Vibrating Timoshenko Column

A.N. Kounadis

National Technical Univ., Athens, Greece, J. Sound Vib., 73 (2), pp 177-184 (Nov 22, 1980) 2 figs, 17 refs

**Key Words:** Beams, Timoshenko theory, Equations of motion, Principle of virtual work, Hamiltonian principle

A pair of coupled differential equations is established governing the motion of an elastically restrained Timoshenko beam carrying a concentrated mass and subjected to a compressive follower load at its end and to a uniformly distributed compressive follower load, by using the principle of virtual work and Hamilton's principle for non-conservative systems. Moreover, a different set of equations of motion is obtained on the basis of the free body diagram of a Timoshenko beam element with sides not perpendicular to the deflected axis of the beam.

#### 81-1249

#### Natural Frequencies of Bernoulli-Euler Beams Resting on Two Elastic Supports: Application to Railway Vehicles

J. Richard

Laboratoire de Mecanique et Technologie, Universite P.M. Curie (Paris VI) - Enset, 61, Avenue du President Wilson, 94230 Cachan, France, Vehicle Syst. Dyn., 9 (6), pp 309-326 (Dec 1980) 5 figs, 2 tables, 8 refs

**Key Words:** Beams, Elastic foundations, Bernoulli-Euler method, Natural frequencies, Flexural vibrations, Railroad cars

The purpose of the present study is to investigate the effect of the different parameters of the elastic supports upon which a deformable beam lies, upon the natural frequencies of the system. The influence of support parameters is ob-

#### 81-1250

#### Forced Vibrations of Layered Beam

O. Simkova and S. Markus

Inst. of Machine Mechanics, Slovak Academy of Sciences, Bratislava, Czechoslovakia, Strojnický Časopis, 31 (6), pp 681-693 (1980) 4 figs, 2 tables, 3 refs

(In Slovak)

**Key Words:** Beams, Layered materials, Flexural vibration

In the contribution the dynamic response of three-layered, simply supported beam is analyzed. Flexural vibrations are created by an external excitation. Flexural and shear deformations in all three layers of the beam are taken into account. Equations of motion of damped vibrations of the system are derived by aid of Hamilton's principle. The influence of distribution of the excitation upon the resonant response of the system is treated from the point of view of its minimalization.

#### 81-1251

#### Static and Dynamic Tests of Full Scale Double-Tee Girders for Dade County Rapid Transit System

T.C. Hsu

Dade County Office of Transportation Admn., Miami, FL, Rept. No. UMTA-FL-06-0017-80-1, 164 pp (Oct 1979)

PB81-115388

**Key Words:** Girders, Rapid transit railways, Dynamic tests

Aerial structures to be used for guideways, prestressed concrete double-tee girders, were tested. These tests were to serve three purposes: to prove the adequacy of all design methods; to check some of the construction and reinforcement details; and to verify the dynamic performance of the girders. Demonstration tests were carried out on three full-size 80 feet long by 5 feet deep by 12 feet wide precast prestressed double-tee girders proposed for the aerial guideways.

## CYLINDERS

**81-1252**

### Response of Buried Vertically Oriented Cylinders to Dynamic Loading

G.E. Albritton and J.P. Balsara

Army Engineer Waterways Experiment Station, Vicksburg, MS, 13 pp (June 1980)  
AD-A090 354/2

**Key Words:** Cylinders, Underground structures, Hardened installations, Missile silos, Nuclear weapons effects, Nuclear explosions, Simulation

One of the primary concepts proposed for basing advanced ballistic missile systems is to emplace the missile in a buried vertical cylindrical shelter. Since little data were available on the response of vertically oriented cylinders that could be used to assess the hardness of missile silos, a field test program was conducted by the Structures Laboratory of the U.S. Army Engineer Waterways Experiment Station (WES) to determine the response to failure of generic vertical shelters having different wall construction designs and subjected to effects of simulated nuclear surface overpressure loadings. Results obtained from the simulation program were to provide information to support selection and design of prototype vertical shelters. The specific objective of the field test program was to obtain information whereby cylinder wall construction designs could be ranked as to their survivability/vulnerability. Thus, with such information, the cost performance of the various designs could be determined with structural hardness a major consideration.

**81-1253**

### Aeroelastic Instability of Rectangular Cylinders in a Torsional Mode due to a Transverse Wind

K. Washizu, A. Ohya, Y. Otsuki, and K. Fujii

Dept. of Aeronautics, Univ. of Tokyo, Tokyo, Japan, J. Sound Vib., 72 (4), pp 507-521 (Oct 22, 1980)  
12 figs, 3 tables, 10 refs

**Key Words:** Cylinders, Torsional response, Mode shapes, Free vibration, Forced vibration, Wind tunnel tests

This paper reports results of wind tunnel experiments on the aeroelastic instability in a torsional mode of two-dimensional rectangular cylinders in a uniform, transverse, two-dimensional flow. Both the free oscillation method and the forced oscillation method were employed for the experiments. Emphasis has been placed on finding the effect of the chord to thickness ratio  $c/d$ , and also that of the structural damping, on the aeroelastic instability phenomena in the vicinity of the resonance speed.

**81-1254**

### The Calculation of Hydrodynamic Forces Acting on a Deformable Cylinder in the Free Surface

B.-K. Yu

Ph.D. Thesis, Univ. of California, Berkeley, 85 pp (1979)  
UM 8029636

**Key Words:** Cylinders, Hydrodynamic excitation, Underwater structures, Water waves, Fluid-induced excitation, Boundary value problems

Boundary-value problems associated with the deformation of an infinite cylinder in a free surface are formulated. These problems include vibration in still water and deformation due to wave-induced forces. The amplitude of deformation is assumed to be small enough for linear theory to be applicable. The deformation itself is assumed to vary sinusoidally along the length of cylinder and arbitrarily girthwise. With the application of Green's theorem for an unbounded fluid, each boundary-value problem results in a Fredholm integral equation of the second kind. The integral equation can be solved numerically using a distribution of oscillatory-source Green functions on the periphery of the submerged surface. In this technique, Frank's close-fit method is extended to treat non-rigid body deformations. Hydrodynamic pressure distributions created by the arbitrary deformation of a cylinder have been calculated. The results show that these hydrodynamic pressures are quite dependent on the shape of the deformation pattern and are also quite sensitive to the longitudinal periodicity. In addition, wave-power absorption in oblique waves is evaluated. The computer program developed for a deformable body can treat two-dimensional, rigid-section motions and also motions with an arbitrary amplitude distribution around the cross-section.

## PANELS

(Also see No. 1218)

**81-1255**

### Inelastic Seismic Analysis of Large Panel Structures

V. Schricker

Ph.D. Thesis, Univ. of California, Berkeley, 245 pp (1980)  
UM 8029581

**Key Words:** Buildings, Panels, Earthquake response, Walls, Joints (junctions), Seismic analysis, Computer programs

Large panel structures are increasingly being built throughout the world, yet little is known about their performance under earthquake motions, particularly their ability to survive very strong shaking. Large panel structures behave differently

from frame and monolithic wall structures, because of the distinct planes of weakness in the horizontal and vertical joints between panels. These joints may slide and open during shaking, producing large localized changes in the bending and shear stiffnesses. A mathematical model for inelastic seismic analysis of two-dimensional large panel structures is developed. The wall panels are idealized either as elastic beams or by two-dimensional finite elements. The joints are idealized by nonlinear spring elements with a variety of force-deformation relationships. Several panel and joint elements have been developed, and incorporated into the computer program DRAIN-2D. A parameter study has been carried out on a multi-story, single bay, large panel wall, to determine the influence of design and analysis assumptions on the computed nonlinear response, considering both slip and opening at the joints. The results show that nonlinear joint behavior has a large effect on the computed response, and that the response depends greatly on the modeling assumptions.

## PLATES

(Also see Nos. 1173, 1178)

### 81-1256

#### Diffraction of a Spherical Wave by a Thin Infinite Plate

H. Saadat and P. Filippi

Djondichapour Univ., Faculty of Sciences, Kouye Golestan Ahwaz, Iran, J. Acoust. Soc. Amer., 69 (2), pp 397-403 (Feb 1981) 13 refs

**Key Words:** Plates, Wave diffraction, Harmonic excitation

A thin elastic plate extending to infinity is immersed in a perfect gas. The response of this system to a spherical harmonic sound source is studied, and an exact representation of the solution is developed. From this result, a series representation useful to calculate the farfield is established; expressions for the various mean powers are given.

### 81-1257

#### Free Vibration of Curved-Plate Assemblies with Diaphragm Ends

I.R. Morris and D.J. Dawe

Dept. of Civil Engrg., Univ. of Birmingham, Birmingham B15 2TT UK, J. Sound Vib., 73 (1), pp 1-17 (Nov 8, 1980) 6 figs, 3 tables, 9 refs

**Key Words:** Plates, Curved plates, Strips, Finite strip method, Natural frequencies

The finite strip method is applied to the prediction of the natural frequencies of vibration of longitudinally invariant, rigidly connected assemblages of circularly curved and flat (zero curvature) strips having diaphragm end supports. Two related types of refined, transversely curved finite strip are described. Both are based on quintic polynomial interpolation across the strip of the radial and tangential components of displacement, whilst the axial component is interpolated in cubic fashion for one type of strip and in quintic fashion for the other. Results are presented for a limited range of problems, including the circular cylinder, and these demonstrate the high accuracy that can be achieved with the use of very few strips.

### 81-1258

#### Active Control of Vibration in Rotating Circular Discs

C.J. Radcliffe

Ph.D. Thesis, Univ. of California, Berkeley, 128 pp (1980)

UM 8029549

**Key Words:** Disks (shapes), Vibration control, Active control, Flexural vibration, Circular saws

A new method of using external forces to control the transverse vibration of centrally-clamped rotating circular discs is presented. Centrally-clamped discs are the basic element of steam and gas turbines, grinding wheels, circular saws and computer disc memories. Large amplitude transverse vibration can cause failure of turbine wheels due to wheel-to-case contact, cutting inaccuracy in grinding wheels and circular saws, and head tracking errors in computer disc memories. This investigation of transverse vibration control was stimulated by the need to operate thin but stable saws in the wood processing industry. Although focused on circular saws, this work has application in all the above systems.

### 81-1259

#### Flexural Vibrations of Free Circular Plates Elastically Constrained Along Parts of the Edge

Y. Narita and A.W. Leissa

Dept. of Engrg. Mechanics, Ohio State Univ., Columbus, OH 43210, Intl. J. Solids Struc., 17 (1), pp 83-92 (1981) 5 figs, 2 tables, 21 refs

**Key Words:** Plates, Circular plates, Flexural vibrations, Free vibration, Elastic foundations

The present paper deals with the free transverse vibration of a circular plate elastically constrained along parts of its

edge and free on the remainder. The elastic constraints considered permit both translational and/or rotational springs of space-varying stiffness. The analytical method utilized depends upon expanding both piecewise constant spring stiffnesses in the present problem into their Fourier components around the circumference of the plate. Numerical results are presented which demonstrate the effectiveness of the method and show interesting variations of the frequencies and nodal patterns over a range of constraint parameters. As special cases, numerical results are also given for the problem of the plate which is partially free and partially simply supported, as well as for the clamped-free boundary.

### 81-1260

#### Axisymmetric Free Vibration of Thick Annular Plates

K.T.S.R. Lyengar and P.V. Raman

Dept. of Civil Engrg., Indian Inst. of Science, Bangalore 560012, India, J. Acoust. Soc. Amer., 68 (6), pp 1748-1749 (Dec 1980) 1 fig, 2 tables, 6 refs

**Key Words:** Plates, Annular plates, Free vibration, Method of initial functions

Free vibration of annular plates has been studied using the method of initial functions. Numerical results of the natural frequencies are obtained for two typical support conditions. The present results depart from the classical plate theory for higher modes as well as for thicker plates, but is in good agreement with Mindlin's improved plate theory.

the plate. Once the matrix has been determined by numerical integration of the equations, the natural frequencies and the critical flutter loads are calculated numerically in terms of the elements of the matrix for a given set of boundary conditions at the edges of the plate. This method is applied to annular plates of linearly, parabolically or exponentially varying thickness, and the effects of the varying thickness, inner/outer radii ratio and edge conditions are studied.

### 81-1262

#### Natural Frequencies of Stepped Thickness Rectangular Plates

T. Irie, G. Yamada, and H. Ikari

Dept. of Mech. Engrg., Hokkaido Univ., North-13, West-8, Sapporo 060, Japan, Int'l. J. Mech. Sci., 22 (12), pp 767-777 (1980) 8 figs, 3 tables, 13 refs

**Key Words:** Plates, Rectangular plates, Variable cross section, Natural frequencies, Mode shapes

This paper presents the natural frequencies of stepped thickness square and rectangular plates together with the mode shapes of vibration. The transverse deflection of a stepped thickness plate is written in a series of the products of the deflection functions of beams parallel to the edges satisfying the boundary conditions, and the frequency equation of the plate is derived by the energy method. By use of the frequency equation, the natural frequencies (the eigenvalues of vibration) and the mode shapes are calculated numerically in good accuracy for square and rectangular plates with edges simply supported or elastically restrained against rotation, having square, circular or elliptical stepped thickness, from which the effects of the stepped thickness on the vibration are studied.

### 81-1261

#### Vibration and Stability of a Non-Uniform Annular Plate Subjected to a Follower Force

T. Irie, G. Yamada, and Y. Kaneko

Dept. of Mech. Engrg., Hokkaido Univ., Sapporo, Japan, J. Sound Vib., 73 (2), pp 261-269 (Nov 22, 1980) 6 figs, 2 tables, 12 refs

**Key Words:** Plates, Annular plates, Variable cross section, Follower forces, Transfer matrix method, Flexural vibration, Natural frequencies

This paper presents a study on the vibration and dynamic stability of a non-uniform annular plate subjected to a follower force radially distributed at the outer edge, in which the transfer matrix method is used. The equations of flexural vibration of the plate are written in a coupled set of first-order differential equations by using the transfer matrix of

### 81-1263

#### Upper and Lower Bounds for the Frequencies of Clamped Orthotropic Plates

J.R. Kuttler and V.G. Sigillito

Applied Physics Lab., The Johns Hopkins Univ., Johns Hopkins Rd., Laurel, MD 20810, J. Sound Vib., 73 (2), pp 247-259 (Nov 22, 1980) 4 tables, 9 refs

**Key Words:** Rectangular plates, Plates, Orthotropism, Low frequencies

Upper and lower bounds are given for the three lowest frequencies of vibration of clamped rectangular orthotropic plates. The bounds were obtained by using a recently devel-

oped method which gives estimates for the vibrational frequencies in terms of easily evaluated integrals of trial functions. Important features of the method are that rigorous, improvable upper and lower bounds on the frequencies are obtained and that the trial functions need not satisfy any boundary conditions.

#### 81-1264

#### Note on the Stability of Vibrations of Rectangular Plates with Initial Imperfections

V. Birman

Dept. of Aeronautical Engrg., Technion -- Israel Inst. of Tech., Haifa, Israel, Israel J. Tech., 17 (5/6), pp 354-359 (1979) 7 figs, 11 refs

**Key Words:** Plates, Rectangular plates, Initial deformation effects, Flexural vibration

In this paper the influence of the nonlinear transverse vibration on the stability of statically compressed plates with initial imperfections is investigated. The dynamic variant of Karmen's equations for an imperfect plate is used in studying the stability of forced vibration. It is shown numerically that the vibration of an imperfect statically compressed plate in the presence of compressive forces below the critical level may be unstable.

#### 81-1265

#### Transient Response of Undamped Laminated Plates

A.S. Grover and A.D. Kapur

Dept. of Mech. Engrg., Punjab Engrg. College, Chandigarh, India, Strojnický Časopis, 31 (5), pp 567-578 (1980) 8 figs, 14 refs

**Key Words:** Plates, Layered materials, Elastic core-containing media, Transient response

Transient response of a three-layer simply supported laminated plate with elastic core subjected to half-sine pulse acceleration has been analyzed using a variational method. The effect of transverse inertia only has been considered. Values of the transverse displacement response have been plotted to study the dynamic behavior of the laminated plate when different system parameters are varied.

#### 81-1266

#### Thermally Induced Vibrations of a Viscoelastic Plate

J. Mazumdar, D. Hill, and D.L. Clements

Dept. of Appl. Mathematics, The Univ. of Adelaide, Adelaide, South Australia 5001, Australia, J. Sound Vib., 73 (1), pp 31-39 (Nov 8, 1980) 4 figs, 13 refs

**Key Words:** Plates, Viscoelastic properties, Thermal excitation

A method for the study of thermally induced vibrations of a viscoelastic plate of arbitrary shape is proposed. The method is based upon the concept of iso-amplitude contour lines on the surface of the plate. It is shown that the time behavior can be found by assuming a normal mode expansion in terms of the eigenfunctions for the associated elastic plate problem, and the deflection is obtained by using the elastic-viscoelastic analogy. As an illustration of the technique, the vibration of a viscoelastic circular plate under a thermal shock at its center is discussed, all details of which are illustrated by graphs.

#### 81-1267

#### Study of the Transient Motion in the Cochlea

M.H. Holmes

Dept. of Math. Sciences, Rensselaer Polytechnic Inst., Troy, NY 12181, J. Acoust. Soc. Amer., 69 (3), pp 751-759 (Mar 1981) 7 figs, 16 refs

**Key Words:** Ears, Plates, Fluid-induced excitation, Transient response

The transient problem obtained from a three-dimensional hydroelastic model of the cochlea is studied. In the model, the fluid motion is described by the linearized Navier-Stokes equations, and the basilar membrane is modeled as an elastic plate. The resulting problem is first reduced through the use of a slender body approximation which is, in turn, simplified by introducing expansions in terms of the reciprocal of the Reynolds number. With this, the wave-like nature of the solution is analyzed, comparing it with the long-time solution, as well as with experiment.

#### 81-1268

#### Vibrations of Mindlin's Circular Plates with Thickness Varied along Radius

S. Takahashi, K. Suzuki, and T. Yamaguchi

Faculty of Engrg., Yamagata Univ., Yonezawa, Japan, Bull. JSME, 24 (187), pp 229-235 (Jan 1981) 1 fig, 3 tables, 15 refs

**Key Words:** Plates, Circular plates, Variable cross section, Mindlin theory, Flexural vibration

The vibrations of circular plates with variable thickness are studied by the method of Mindlin's thick plate theory. The vibration problems of circular plates with two or more nodal diameters are solved in the case that the thickness is varied exponentially, the effects of some parameters on frequencies are discussed and some frequencies are compared with those from the classical theory.

of the edges in the form of a square pulse. The influence of the initial plate irregularities on the overall response during both loading and postloading period is investigated. The averaged in-plane inertia forces are taken into account. The analysis is an extension of the studies of the response to in-plane normal forces of plates of infinite width and finite length given in, and of a finite plate given in. The results indicate that the frequency spectra of free vibrations during the post-loading regime are controlled by the initial irregularities distribution, plate geometry and the load levels.

### 81-1269

#### **Finite Element Analysis of a Dynamically Loaded Flat Laminated Plate**

A.R. Zak and D.W. Pillausch

Dept. of Aeronautical and Astronautical Engrg., Illinois Univ. of Urbana-Champaign, IL, Rept. No. ARBRL-CR-00433, AD-E430, 124 pp (July 1980) AD-A089 985/6

**Key Words:** Plates, Layered materials, Finite element technique

A finite element structural model has been developed for the dynamic analysis of laminated, thick plates. The model uses quadrilateral elements to represent the shape of the plate and the elements are stacked in the thickness direction to represent various material layers. This analysis allows for orthotropic, elastic-plastic or elastic-viscoplastic material properties. Non-linear strain displacement relations are used to represent large transverse plate deflections. A finite difference technique is used to perform the numerical time integration. The results from the analytical model are compared with experimental results. A good agreement is found between the calculated and measured values of the transverse plate deflections.

### 81-1270

#### **Dynamic Shear Response of Rectangular Plates with Initial Imperfections**

H. Pasic and G. Herrmann

Div. of Applied Mechanics, Dept. of Mech. Engrg., Stanford Univ., Stanford, CA 94305, J. Mech. Des., Trans. ASME, 102 (4), pp 769-775 (Oct 1980) 4 figs, 1 table, 9 refs

**Key Words:** Plates, Rectangular plates, Initial deformation effects, Shear waves, Pulse excitation

The paper presents an analysis of the elastic response of a simply supported, imperfect, rectangular plate subjected to an in-plane supercritical shear force, suddenly applied at one

### 81-1271

#### **Near Field Measurement of the Complex Radiation Impedance Presented to a Vibrating Plate in a Reverberant Room Containing a Rotating Diffuser**

C.H. Hansen and D.A. Bies

Dept. of Mech. Engrg., Univ. of Adelaide, Adelaide, South Australia 5000, Australia, J. Sound Vib., 73 (1), pp 79-101 (Nov 8, 1980) 12 figs, 1 table, 29 refs

**Key Words:** Plates, Vibrating structures, Mechanical impedance, Testing techniques, Measurement techniques

The radiation impedance presented by the field of a reverberant room to a rectangular plate mounted in a large baffle and vibrating in its fundamental simply supported edge mode is experimentally investigated. It is shown that a large diffuser rotating at 30 rpm causes large variations in both the real and imaginary parts of the radiation impedance but the average values agree very well with values obtained in the free field of an anechoic room. The real part of the radiation impedance is in good agreement with theoretical prediction. The experimental method makes use of a time average hologram of the mode stored in computer memory, a single point acceleration measurement on the plate, and a surface pressure scan. The method allows investigation of side band frequencies generated by the plate in the presence of the rotating diffuser. It is shown that these side band frequencies contain negligible energy and that they are the result of the cyclic amplitude modulation of the power radiated by the plate.

### 81-1272

#### **Nonlinear Third Harmonic Resonance of Flexural Waves on a Waveguide of Thin Elastic Plate**

N. Sugimoto and Y. Majima

Dept. of Mech. Engrg., Faculty of Engrg. Science, Osaka Univ., Toyonaka, Osaka 560 Japan, J. Acoust. Soc. Amer., 69 (2), pp 410-415 (Feb 1981) 1 fig, 13 refs

**Key Words:** Plates, Waveguides, Flexural waves, Harmonic response, Resonant response

The nonlinear third harmonic resonance of flexural waves on a waveguide of a thin elastic plate of infinite length is investigated based on a theory of large deflection of a plate. Two types of waveguide are treated, one having both side edges supported simply and the other having both side edges fixed. Since the nonlinearity in flexural motions of a thin plate is cubic in a deflection, a quasimonochromatic flexural wave and its third harmonic wave can interact resonantly due to the nonlinearity at such a frequency that both waves can propagate simultaneously. The stationary solutions of the resonance equations show that two wave amplitudes vary periodically to exchange their energy, including solitary waves as limiting cases. Under a special condition, an "algebraic solitary wave" is also possible.

This report provides an evaluation of dynamic sloshing loads in slack LNG cargo tanks. A comprehensive review of worldwide scale model sloshing data is presented. The data are reduced to a common format for the purposes of defining design load coefficients. LNG tank structural details are reviewed with emphasis placed on defining unique design features which must be considered in designing LNG tanks to withstand dynamic sloshing loads. Analytical studies are undertaken to provide techniques for determining wall structural response to dynamic slosh loads. Finally, design methodology is presented for membrane and semi-membrane tanks, gravity tanks, and pressure tanks whereby the design procedures sequences from comparing resonant sloshing periods to ship periods, defining the design loads, and designing the tank structures affected by dynamic slosh loads by delineated procedures which vary with tank type.

#### **81-1273**

#### **Laser Speckle Method for the Analysis of Steady State Vibration of Plates**

C.J. Lin and F.P. Chiang

Dept. of Mech. Engrg., State Univ. of New York at Stony Brook, Stony Brook, Long Island, NY 11794, J. Acoust. Soc. Amer., 69 (2), pp 456-459 (Feb 1981) 4 figs, 15 refs

**Key Words:** Plates, Vibration measurement, Measurement techniques

A laser speckle method is described whereby time-average slope contours are obtained from vibrating plates. It has an advantage over deflection contouring methods in that only first-order differentiation of experimental data is needed for stress calculations.

## **SHELLS**

#### **81-1274**

#### **Evaluation of Liquid Dynamic Loads in Slack LNG Cargo Tanks**

P.A. Cox, E.B. Bowles, and R.L. Bass

Southwest Res. Inst., San Antonio, TX, Rept. No. SWRI-SR-1251, SSC-297, 201 pp (May 1980) AD-A091 153/7

**Key Words:** Tanks (containers), Cargo transportation, Sloshing

#### **81-1275**

#### **Axisymmetric Free Vibration Analysis of a Circular Cylindrical Tank**

H. Kondo

Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan, Bull. JSME, 24 (187), pp 215-221 (Jan 1981) 4 figs, 3 tables, 14 refs

**Key Words:** Tanks (containers), Cylindrical shells, Fluid filled containers, Sloshing, Fluid-induced excitation

Coupled oscillations of a liquid and a structure of a circular cylindrical tank are studied for small motions. The liquid is assumed as a perfect fluid, the side wall of the tank is treated as an elastic circular cylindrical shell, and the tank bottom is assumed rigid. Velocity potential is introduced to express liquid motions in series expansions of an orthogonal system. Frequency equations are obtained from a kinematical condition along the side wall and numerically solved to illustrate the effect of coupling, showing that at lower eigenfrequencies the motions are mainly due to liquid surface sloshing, and that at higher eigenfrequencies emerge so-called bulging modes consisting mainly of sinusoidal motions of the side wall.

#### **81-1276**

#### **Point Admittance of Cylindrical Shells with and without Ring-Stiffening**

E.C. Eichelberger

Gannett Fleming Corddry and Carpenter, Inc., Harrisburg, PA, ASME Paper No. 80-WA/NC-5

**Key Words:** Shells, Cylindrical shells, Stiffened shells, Rings, Mechanical admittance

The dynamical response of two cylindrical shells, one with and one without ring-stiffening, was investigated. Particular attention was placed on the use of ring-stiffening to provide velocity insertion loss at the point of excitation. The driving-point admittance was measured and compared with predictions using the Mean-Value Admittance Method. This method predicts the geometric-mean of the response of a vibrator with respect to frequency, and is valid at low as well as high frequencies.

ainers with free liquid surfaces is presented, where the natural frequencies of new tank forms are shown. In addition, the procedure whereby these natural frequencies are determined, is presented for the circular cylinder completely filled with two liquids of different densities and having a separating cross-wall which may be treated as a flexible membrane or an elastic thin plate.

### 81-1277

#### **Finite Element Analysis of Earthquake-Induced Sloshing in Axisymmetric Tanks**

M. Aslam

Bechtel Power Corp., San Francisco, CA, Intl. J. Numer. Methods Engrg., 17 (2), pp 159-170 (Feb 1981) 7 figs, 24 refs

**Key Words:** Tanks (containers), Fluid-filled containers, Sloshing, Earthquake response, Finite element technique

A finite element analysis to predict the sloshing displacements and hydrodynamic pressures in liquid-filled tanks subjected to earthquake ground motions is presented. Finite element equations were derived using the Galerkin formulation, and the predicted results were checked against the test data, showing a good agreement between the test and finite element results.

### 81-1279

#### **Sloshing of Liquids in Rigid Annular Cylindrical and Torus Tanks Due to Seismic Ground Motions**

M. Aslam, W.G. Godden, and D.T. Scalise

Bechtel Corp., San Francisco, CA, Rept. No. CONF-800919-2, 9 pp (Jan 1980) LBL-10351

**Key Words:** Tanks (containers), Fluid-filled containers, Sloshing, Seismic excitation, Finite element techniques

Sloshing response and impulsive hydrodynamic pressures in rigid axisymmetric tanks due to horizontal ground motions are predicted by theoretical solutions based on series and finite element analysis. Results are compared with experimental data from model tests conducted on a 20 ft x 20 ft earthquake simulator.

### 81-1278

#### **Dynamic Behaviour of an Elastic Separating Wall in Vehicle Containers: Part I**

H.F. Bauer

Fachbereich Luft- und Raumfahrttechnik, Hochschule der Bundeswehr, Munich, W. Germany, Intl. J. Vehicle Des., 2 (1), pp 44-77 (Feb 1981) 19 figs, 8 refs

**Key Words:** Semitrailers, Tanks (containers), Fluid-filled containers, Natural frequencies, Sloshing

The motion of liquids carried in semitrailer tank systems is a very frequent cause of road accidents. Even in completely filled containers with flexible separating cross-walls, the dynamics of the elastic structure and liquid interaction may result in vehicle handling difficulties. For this reason emphasis is put on cylindrical and rectangular containers, for which the basic equations are presented. In this first part of a two-part paper, a short review of liquid motions in various con-

### 81-1280

#### **Dynamic Instability of Suddenly Heated Cylindrical Shells**

H. Ray and E.G. Lovell

Rutgers Univ., Piscataway, NJ 08854, Nucl. Engrg. Des., 61 (2), pp 237-243 (Nov 1980) 7 figs, 6 refs

**Key Words:** Shells, Cylindrical shells, Thermal excitation

The stability of the motion of thin elastic isotropic circular cylindrical shells subjected to suddenly developed temperatures is investigated. The excitation of particular unstable modes is identified from an evaluation of parameters in the equations of motion representing short term response. These are functions of the geometry of shell, the properties of material and temperature. The long term nonlinear analysis shows that the initially unstable circumferential flexural modes exchange energy with the circular mode in a cyclic manner. This response generally gives rise to displacements and stresses that are much larger than those associated with the basic linear motion of the shell.

**81-1281**

**A Consistent Set of Trial Functions for Conical Shells**

M. El-Raheb and P. Wagner

Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA 91103, J. Sound Vib., 73 (1), pp 103-112 (Nov 8, 1980) 1 fig, 1 table, 10 refs

**Key Words:** Shells, Conical shells, Shells of revolution, Non-linear theories

A consistent approach is developed for the determination of trial functions for a class of shells of revolution. The trial functions satisfy the in-plane and out-of-plane boundary conditions at the shell ends and include the effects of tangential inertia. The resulting expressions converge rapidly for the problem of linear free vibration.

In this paper a double summation procedure for the multiple response spectrum method of seismic analysis is derived. The theoretical basis and approximations involved are discussed.

**81-1282**

**Nonlinear Vibration of Circular Cylindrical Shells  
(Die Nichtlineare Schwingung von Kreiszylinderschalen)**

N.X. Hung

Technical University of Hanoi, Rev. Roumaine Sci. Tech., Mecanique Appl., 25 (1), pp 67-73 (1980) 23 figs, 3 refs

(In German)

**Key Words:** Shells, Cylindrical shells, Large amplitudes

Forced vibrations of circular cylindrical shells with large amplitudes under simultaneous static and dynamic loads are investigated.

**PIPES AND TUBES**

(Also see No. 1393)

**81-1283**

**A Double Summation Procedure for the Combination of Seismic Responses of Multiply-Excited Piping Systems**

C. Sundararajan

EDS Nuclear, Inc., San Francisco, CA, ASME Paper No. 80-WA/PVP-1

**Key Words:** Piping systems, Seismic analysis, Response spectra, Double summation procedure

**81-1284**

**Further Numerical Studies on Dynamic Circumferential Crack Propagation in a Large Pipe**

H. Awaji, A.S. Kobayashi, A.F. Emery, W.J. Love, and B.L. Kistler

Univ. of Washington, Seattle, WA, ASME Paper No. 80-WA/PVP-6

**Key Words:** Pipes (tubes), Crack propagation

The results of this paper and the results of previous dynamic ductile circumferential crack propagation in the 18-in.-dia 316 stainless steel pipe suggest that crack propagation in the presence of large-scale yielding is controlled mainly by the rotary inertia of the two fracturing pipe segments.

**81-1285**

**Dynamic Crack Propagation in Very Ductile Materials - The Influence of Inertia**

M. Perl, A.F. Emery, A.S. Kobayashi, and W.J. Love

Univ. of Washington, Seattle, WA, ASME Paper No. 80-WA/PVP-8

**Key Words:** Pipes (tubes), Crack propagation

The comparison of recent calculations for the propagation of axial cracks in pressurized pipes with experimental data suggest that the crack growth is governed by the inertia of the separating parts. In order to study the validity of this conclusion for other configurations, the basic problem of a tensile plate was analyzed and the results reported.

**81-1286**

**Self-Sustained Oscillations of Turbulent Pipe Flow Terminated by an Axisymmetric Cavity**

A. Schachenmann and D. Rockwell

Dept. of Mech. Engrg. and Mechanics, Lehigh Univ.,

Bethlehem, PA 18015, J. Sound Vib., 73 (1), pp 61-72 (Nov 8, 1980) 9 figs, 13 refs

**Key Words:** Pipes (tubes), Self-excited vibrations

Turbulent flow through a long pipe terminated by an axisymmetric cavity can give rise to self-sustained oscillations exhibiting a very strong coherence, as evidenced by the narrowband character of corresponding amplitude spectra. These oscillations, associated with the turbulent axisymmetric jet passing through the cavity, are discussed.

#### 81-1287

#### Calculate Natural Frequency of Internal Lined Pipe

K.T. Truong and P.T. Tran

SNC/FW Ltd., Montreal, Quebec, Canada, Hydrocarbon Processing, 59 (12) pp 94-96 (Dec 1980) 2 figs, 2 tables, 4 refs

**Key Words:** Natural frequencies, Pipes (tubes), Linings, Fossil power plants

Natural frequency calculations of internal lined pipe are needed to minimize vibration problems in units where erosion is a problem. The method presented will also be very useful for minimizing these problems in future coal processing plants.

#### 81-1288

#### Row Depth Effects on Turbulence Spectra and Acoustic Vibrations in Tube Banks

J.A. Fitzpatrick and I.S. Donaldson

Dept. of Mech. Engrg., The University, Glasgow G12 8QQ, Scotland, J. Sound Vib., 73 (2), pp 225-237 (Nov 22, 1980) 10 figs, 8 refs

**Key Words:** Tubes, Multi beam systems, Ducts, Heat exchangers, Fluid-induced excitation

The effect of row depth on Strouhal numbers derived from peaks in the turbulence spectra measured in an in-line tube bank and on the excitation of acoustic standing waves in the duct containing the bank has been investigated. The results indicate significant variations with bank depth and location in the bank although common features are evident.

#### 81-1289

#### Modelling of Coulomb Damping and Wear of Vibrating Systems

G. Levy

CEGB Berkeley Nuclear Labs., Berkeley, Glos, UK, Wear, 64 (1), pp 57-82 (Oct 1980) 15 figs, 9 refs

**Key Words:** Tubes, Nuclear reactors, Coulomb damping

Coulomb damping, often relied upon to control the response of nuclear boiler tube banks acted upon by fluctuating eddy forces from turbulent coolant flow, is modeled. The required energy dissipation is affected by relative sliding movements between the clamped joints of the tube and support structure. These movements are in general related to the center span deflection which is coupled to the exciting forces by coupling coefficients. Specific models of the damping are developed for direct Coulomb damping and second-order damping under conditions where a constant friction force, i.e. static loading, is assumed to act. The effects of partial slip across the joint are examined, and this gives rise to a damping contribution at amplitudes that lie below the threshold for gross slip at the joint.

#### DUCTS

(Also see Nos. 1234, 1288)

#### 81-1290

#### Vibration and Heat Transfer from a Circular Duct

E. Janotkova and V. Ennenkl

Faculty of Mech. Engrg., Tech. Univ. Brno, Czechoslovakia, Strojnický Časopis, 31 (5), pp 623-633 (1980) 5 figs, 12 refs

**Key Words:** Ducts, Vibration excitation, Heat generation

The paper deals with the results of the experimental investigation of the forced convection heat transfer from a horizontal cylindrical duct with smooth and rough surfaces, subjected to vibration. Analysis of data proved that vibration caused the convective heat transfer to increase and that the vibration effect is directly comparable for smooth and rough duct surfaces.

#### 81-1291

#### Application of the Equivalent Surface Source Method to the Acoustics of Duct Systems with Non-Uniform Wall Impedance

M. Namba and K. Fukushige

Dept. of Aeronautical Engrg., Kyushu Univ., Hakozaki, Higashi-ku, Fukuoka 812, Japan, J. Sound Vib., 73 (1), pp 125-146 (Nov 8, 1980) 17 figs, 6 refs

**Key Words:** Ducts, Acoustic linings, Turbofan engines, Equivalent surface source method

The paper outlines the application of the equivalent surface source method to the analysis of the acoustic field in a partially lined duct with arbitrarily non-uniform wall impedance. Lined sections of the duct wall are represented by unsteady mass source singularities, the strengths of which are determined by solving integral equations. The method is applicable to lined walls of impedance which is non-uniform in the streamwise and/or circumferential direction. Numerical examples are given to show the effects of various design parameters on sound attenuation. Some advantageous features of circumferentially non-uniform wall impedance are demonstrated.

circumferential liner segmentation simultaneously. The feasibility of a 3-D duct acoustics model was investigated using Galerkin or least squares element formulations combined with Gaussian elimination, successive over-relaxation, or conjugate gradient solution algorithms on conventional scalar computers and on a vector machine. A least squares element formulation combined with a conjugate gradient solver on a CDC Star vector computer initially appeared to have great promise, but severe difficulties were encountered with matrix ill-conditioning. These difficulties in conditioning rendered this technique impractical for realistic problems.

### 81-1292

#### Time-Dependent Difference Theory for Noise Propagation in a Two-Dimensional Duct

K.J. Baumeister

NASA Lewis Res. Ctr., Cleveland, OH, AIAA J., 18 (12), pp 1470-1476 (Dec 1980) 5 figs, 1 table, 36 refs

**Key Words:** Ducts, Sound transmission, Sound attenuation, Time-dependent parameters

A time-dependent numerical formulation is derived for sound propagation in a two-dimensional, straight, soft-walled duct in the absence of mean flow. The time-dependent governing acoustic-difference equations and boundary conditions are developed along with the maximum stable time increment. Example calculations are presented for sound attenuation in hard- and soft-wall ducts. The time-dependent analysis has been found to be superior to the conventional steady numerical analysis because of much shorter solution times and the elimination of matrix storage requirements.

### 81-1294

#### Acoustic Plane Waves Incident on an Oblique Clamped Panel in a Rectangular Duct

H. Unz and J. Roskam

Dept. of Aerospace, Kansas Univ., Lawrence, KS, Rept. No. KU-FRL-417-14, NASA-CR-163624, 137 pp (Aug 1980)  
N80-34215

**Key Words:** Ducts, Rectangular bodies, Elastic waves, Panels, Plates, Sound transmission loss, Noise transmission

The theory of acoustic plane waves incident on an oblique clamped panel in a rectangular duct was developed from basic theoretical concepts. The coupling theory between the elastic vibrations of the panel (plate) and the oblique incident acoustic plane wave in infinite space was considered in detail, and was used for the oblique clamped panel in the rectangular duct. The partial differential equation which governs the vibrations of the clamped panel (plate) was modified by adding to it stiffness (spring) forces and damping forces. The Transmission Loss coefficient and the Noise Reduction coefficient for oblique incidence were defined and derived in detail. The resonance frequencies excited by the free vibrations of the oblique finite clamped panel (plate) were derived and calculated in detail for the present case.

### 81-1293

#### A Feasibility Study of a 3-D Finite Element Solution Scheme for Aeroengine Duct Acoustics

A.L. Abrahamson

Wyle Labs., Hampton, VA, Rept. No. NASA-CR-159359, REPT-51200, 37 pp (Sept 15, 1980)  
N80-34216

**Key Words:** Ducts, Finite element technique, Acoustic linings, Aircraft engines, Acoustic response

The advantage from development of a 3-D model of aero-engine duct acoustics is the ability to analyze axial and

### 81-1295

#### Self-Excited Oscillations of Supersonic Flow in a Sudden Enlargement of a Duct

T. Ikui, K. Matsuo, and H. Mochizuki

Faculty of Engrg., Kyushu Univ., Hakozaki, Fukuoka, Japan, Bull. JSME, 23 (186), pp 1982-1989 (Dec 1980) 13 figs, 8 refs

**Key Words:** Ducts, Self-excited vibrations

The behavior of a shock wave in a supersonic outflow at a sudden enlargement of a duct has been clarified experimen-

tally by a schlieren optical system and static pressure measurements. A self-excited oscillation of flow with a shock wave has been observed at the downstream duct at a particular range of supply pressures in which range the outflowing jet is underexpanded at the sudden enlargement and furthermore the jet does not reattach in the downstream duct.

## BUILDING COMPONENTS

### 81-1296

**The Wolfsburg Model for Vibration Resistance. Part 1: Three Statements for the Description of the Wöhler Field (Das Wolfsburger Modell der Schwingfestigkeit. Teil 1: Drei Ansätze zur Beschreibung des Wöhlerfelds)**

R. Müller

Wolfsburg, Germany, VDI-Z., 122 (18), pp 761-768, (Sept 1980) 6 figs, 3 tables, 15 refs  
(In German)

**Key Words:** Vibration response, Structural elements

The vibratory loads acting on structural elements are a multi-parametric and nonlinear complex quantity and so far inadequately determined. The author describes several mathematical aids to analysis and explains them by means of examples.

### 81-1297

**The Wolfsburg Model for Vibration Resistance. Part 2: Planning and Evaluation of Wöhler Test (Das Wolfsburger Modell der Schwingfestigkeit. Teil 2: Planung und Auswertung des Wöhlerversuchs)**

R. Müller

Wolfsburg, Germany, VDI-Z., 122 (19), pp 841-847 (Oct 1980) 2 figs, 9 tables, 3 refs  
(In German)

**Key Words:** Vibration response, Structural elements

The vibratory resistance of a structure is known when the parameters of its Wöhler field are known. In this paper the instructions for measurement and evaluation of results are illustrated by means of an example. The results obtained by means of a pocket calculator are sufficient as it is shown by a comparison with results obtained by computer analysis.

### 81-1298

**Fatigue and the Effect of Size in Building Components (Ermudungsverhalten und Grosseneinfluss von Bauteilen)**

W. Spath

Speyer, VDI-Z., 122 (21), pp 935-938 (Nov 1980)  
3 figs, 7 refs  
(In German)

**Key Words:** Structural members, Fatigue life, Size effects, Testing techniques

Fatigue strength characteristics, obtained on some test samples, not always are transferrable to actual size building components. A substitution method is proposed and tested to clarify the effect of size in these problems. Then the prediction of fatigue strength on small test samples is compared with the fatigue of actual size building components. Various techniques for testing fatigue of test samples are also described.

## ELECTRIC COMPONENTS

### CONTROLS

#### (SWITCHES, CIRCUIT BREAKERS)

### 81-1299

**The Static and Dynamic Characteristics of LADD Actuators**

S.-T.K. Tzeng

Ph.D. Thesis, The Univ. of Texas at Austin, 188 pp (1980)  
UM 8100979

**Key Words:** Actuators, Mathematical models, Random excitation, Natural frequencies, Mode shapes, Frequency response, System identification techniques

The major contribution of this work is the development of the mathematical model of the LADD for the study of its static and dynamic characteristics and the techniques developed for the experimental testing of this type of actuators. The central contribution of this work is a study of the static and dynamic characteristics of LADD actuators. A mathematical model is developed suitable for predicting the behavior of various LADD configurations including a motor-coupled actuator. Basic conclusions regarding the effects of static and dynamic characteristics on the design of LADD actuated systems are drawn.

## MOTORS

(See No. 1360)

# DYNAMIC ENVIRONMENT

## ACOUSTIC EXCITATION

(Also see Nos. 1184, 1196, 1225, 1231, 1391)

### 81-1300

#### Scattering Theory Approach to the Identification of the Helmholtz Equation: A Nearfield Solution

A.B. Weglein and M.T. Silvia

Cities Service Tech. Ctr., Box 3908, 4500 S. 129th E. Ave., Tulsa, OK 74102, J. Acoust. Soc. Amer., 69 (2), pp 483-488 (Feb 1981) 1 fig, 14 refs

**Key Words:** System identification techniques, Elastic waves, Wave scattering

Expressing the Helmholtz equation as a Schrodinger-type equation with a frequency-dependent potential allows one to use the techniques of inverse scattering to determine the potential from farfield scattering information. These techniques were designed to accommodate farfield experimental data which was generated by a plane-wave probe. The problems of finding the potential when scattering information is restricted to the nearfield and when incident probes are assumed to be arbitrary, unknown, and not necessarily reproducible from experiment to experiment are considered. In this paper, a direct approach to the nearfield inverse scattering problem is presented.

### 81-1301

#### Method for Obtaining a Nearfield Inverse Scattering Solution to the Acoustic Wave Equation

M.T. Silvia and A.B. Weglein

Cities Service Tech. Ctr., Box 3908, 4500 S. 129th E. Ave., Tulsa, OK 74102, J. Acoust. Soc. Amer., 69 (2), pp 478-482 (Feb 1981) 11 refs

**Key Words:** Elastic waves, Wave scattering

Since the classic paper by Gelfand and Levitan in 1955, much has been published on the inverse scattering problem. Assuming no bound states, there are several well-known solu-

tions that reconstruct one-dimensional or spherically symmetric potentials from farfield scattering information. In this paper, work is extended to provide a nearfield inverse scattering solution to the acoustic wave equation. In particular, a procedure is described for obtaining a nearfield inverse scattering solution when the incident probes are arbitrary, unknown, and not necessarily reproducible.

### 81-1302

#### Variational Principles for Dynamic Problems for Inhomogeneous Elastic Media

J.R. Willis

School of Mathematics, Univ. of Bath, Bath BA2 7AY, UK, Wave Motion, 3 (1), pp 1-11 (Jan 1981) 16 refs

**Key Words:** Elastic media, Composite materials, Wave propagation, Variational methods

Some new variational principles for elastodynamic problems, which reduce to the Hashin-Shtrikman principle in the static limit, are presented. They are deduced from dynamical analogues of the classical energy principles of elastostatics by performing appropriate rearrangements and then neglecting certain terms that are quadratic in a measure of the error associated with the approximating trial fields. One of the new principles is then employed to develop equations that provide an approximate description of waves in a random composite.

### 81-1303

#### Reflection and Transmission of Elastic Waves by the Spatially Periodic Interface between Two Solids (Numerical Results for the Sinusoidal Interface)

J.T. Fokkema

Delft Univ. of Tech., Delft, The Netherlands, Wave Motion, 3 (1), pp 33-48 (Jan 1981) 17 figs, 5 tables, 10 refs

**Key Words:** Elastic waves, Wave reflection, Wave transmission, Interface: solid-solid

The integral-equation method for calculating the reflection and transmission of elastic waves by the spatially periodic interface between two solids, developed in a previous paper, is applied to a sinusoidal interface, and numerical results are presented. The computations have been carried out for four different heights of the profile (the plane interface included), a single frequency of operation, two combinations of elastic solids, and the four types of excitation. The interface be-

tween granite and slate, the interface between copper and flint glass, and P- as well as SV-wave incidence in either of the media have been considered.

#### 81-1304

#### Calculation of the Scattering of Elastic Waves from a Penny-Shaped Crack by the Method of Optimal Truncation

W.M. Visscher

Theoretical Div., Los Alamos Scientific Lab., Los Alamos, NM 87545, Wave Motion, 3 (1), pp 49-69 (Jan 1981) 15 figs, 16 refs

**Key Words:** Elastic waves, Wave diffraction, Cracked media, Nondestructive tests

The method of optimal truncation (MOOT), a least-squares boundary-residual method for solving scattering problems, is applied to the plane circular crack. An equatorially cloven spherical inclusion is used to model the crack. Numerical advantages of this model are discussed and demonstrated. Results are given for cross sections for longitudinal waves incident on the crack at arbitrary angles. Both clear cracks and fluid-filled cracks are considered. A refinement of the method which would allow accurate calculation of dynamic stress-intensity factors is developed.

#### 81-1305

#### Elastic Wave Propagation through Multilayered Media

D.E. Chimenti and R.L. Crane

Air Force Materials Lab., Wright-Patterson AFB, OH, Rept. No. AFML-TR-79-4214, 70 pp (Mar 1980)

AD-A088 030/2

**Key Words:** Wave propagation, Layered materials, Elastic waves

This report presents a review of the theory of elastic wave propagation in any number of fluid or solid layered media. Suitable wave equations are derived, and boundary conditions determined by the nature of the media and the character of the interfaces are applied, yielding a formal solution for the transmitted and reflected, longitudinal and transverse wave potentials. Computer-generated graphs are presented which illustrate properties of the solutions in materials of interest in nondestructive evaluation. A tabulation of acoustic-velocity data for media commonly encountered in ultrasonic work is also included.

#### 81-1306

#### Analysis of the Influence of Measuring Point Network on the Estimation Accuracy of a Source Acoustic Power

V. Batko and J. Giergiel

Inst. of Mechanics and Vibroacoustics, Krakow Tech. Univ. of Mining and Metallurgy, Krakow, Poland, Strojnicki Casopis, 31 (6), pp 673-679 (1980) 2 tables

**Key Words:** Noise source identification, Point source excitation

The paper presents an analysis of the effect of measuring point dislocation around a machine on the accuracy assessment of its acoustic power. The investigation is based on the analysis of an isotropic random field formed from the measuring results. For such a model a theorem is cited which facilitates a selection of an optimum sampling point network. The theoretical considerations are illustrated by results gained under free and diffuse field conditions for a network of rectangles, squares and triangles with equal sides.

#### 81-1307

#### A Fundamental Study on Frictional Noise (2nd Report, The Generating Mechanism of Squeal Noise of Higher Modes)

M. Yokoi and M. Nakai

Junior College, Osaka Industrial Univ., Osaka, Japan, Bull. JSME, 23 (186), pp 2118-2124 (Dec 1980) 12 figs, 2 tables, 3 refs

**Key Words:** Noise generation, Friction excitation

In this paper, a frictional noise, produced when a long steel cantilever was pressed in the radial direction on a rotating thick disk is investigated. The results obtained are summarized.

#### 81-1308

#### Diffraction of Sound Around Barriers: Use of the Boundary Elements Technique

R. Seznec

Laboratoire Central des Ponts et Chaussees, Les Bauches du Desert, 44340 Bougenais, France, J. Sound Vib., 73 (2), pp 195-209 (Nov 22, 1980) 9 figs, 2 tables, 15 refs

**Key Words:** Noise barriers, Sound waves, Wave diffraction, Geometric effects

The use of the boundary elements technique permits precise evaluation of the acoustic pressure field diffracted by barriers of different shapes on a flat ground. Absorption conditions on the ground and the barrier may be included easily. Different examples are investigated and excess attenuations obtained by shape changes are compared.

### **81-1309**

#### **Monotonic Curvature of Low Frequency Decay Records in Reverberation Chambers**

K. Bodlund

National Testing Inst., Acoustical Lab., S-501 15  
Boras, Sweden, J. Sound Vib., 73 (1), pp 19-29  
(Nov 8, 1980) 4 figs, 2 tables, 12 refs

**Key Words:** Reverberation chambers, Sound measurement, Low frequencies, Decay laws, Normal modes, Damping

In the papers by Larsen and Brüel, two interesting problems connected with reverberation room measurements are pointed out and discussed. The first problem is that the ensemble averaged decay curve reveals a monotonic curvature at low frequencies. The second phenomenon is that often systematically larger sound power output values are reported at low frequencies according to the free field method than according to the reverberation room method. In searching for an explanation of these anomalies some measurements and a classical normal mode theory analysis have been made.

### **81-1310**

#### **Phenomenology of Sound Propagation through a Green Belt**

R. Makarewicz

Inst. of Acoustics, A. Mickiewicz Univ., 60-796,  
Poznan, Poland, J. Sound Vib., 72 (4), pp 481-489  
(Oct 22, 1980) 6 figs, 2 tables, 6 refs

**Key Words:** Layered materials, Sound propagation

A phenomenological description of wave propagation in some layered media is given. The results have been obtained under the assumption that the wave direction is perpendicular to the layers. Noise propagation over a flat ground surface with a uniform cover of vegetation has been taken as the starting point for further generalizations. The description presented seems to be useful for the other noise control problems relating to the question of the application of "noise screens" composed of homogeneous layers.

### **81-1311**

#### **Estimation of the Mean Power Content of Summed Sinusoids and an Application to Acoustic Noise Measurement in Shallow Water**

A.W. Walker

Admiralty Marine Tech. Establishment, Teddington  
TW11 OLN, UK, J. Sound Vib., 73 (1), pp 41-59  
(Nov 8, 1980) 7 figs, 3 tables, 27 refs

**Key Words:** Underwater sound, Sound measurement

Measurements of physical quantities such as pressure or velocity commonly display significant variations in both space and time. The variation in a single spatial or temporal co-ordinate may often be described by the sum of a finite number of sinusoids of differing wavenumber or frequency, whichever is appropriate. The power average of a small number of random samples is presented as a suitable estimate of the mean power content of such a sum of sinusoids of evenly distributed random argument. Confidence levels which apply to these estimates have been derived by a direct Monte Carlo simulation for three separate cases in which the sinusoids are assumed to have constant equal amplitudes, constant amplitudes which are sample values of an evenly distributed random variable, or constant amplitudes which are sample values of a Gaussian distributed random variable of zero mean and unit variance. Independent checks on the accuracy of the data have been provided by numerical integration in a few special cases. Use of the confidence levels is illustrated by their application to measurements of acoustic source noise taken in shallow water by the appropriate use of vertical arrays of randomly spaced transducers.

### **81-1312**

#### **Display of the Underwater Sound Wavefront Using the Theory of Holographic Interference**

W. Wu

Dept. of Electrical Engrg. and Computer Science,  
Shanghai Jiao Tong Univ., 1954 Hua San Rd., Shanghai 200030, The People's Rep. of China, J. Acoust. Soc. Amer., 69 (2), pp 489-491 (Feb 1981) 5 figs, 3 refs

**Key Words:** Underwater sound, Holographic techniques

Using the theory of holographic interference and the variable properties of the refractive index of water that has been disturbed by wave motion, a method has been developed where two holograms of the underwater acoustic field are photographed successively on one film plate, before and after the introduction of a wave, which could range in frequency from subsonic to supersonic. A He-Ne laser beam is used to illuminate the film plate, and the image of the

wavefront is reconstructed. This new method helps to remove the difficulty underwater acoustic engineers have frequently encountered when observing the scene of an undwater wave.

## SHOCK EXCITATION

(Also see Nos. 1252, 1356, 1373)

### 81-1313

#### Crash Tests of Construction Zone Traffic Barriers

K.C. Hahn and J.E. Bryden

Engrg. Res. and Dev. Bureau, New York State Dept. of Transportation, Albany, NY, Rept. No. FHWA/NY/RR-80/82, 54 pp (June 1980)

PB80-213721

**Key Words:** Guard rails, Dynamic tests, Collision research (automotive)

Three temporary construction zone traffic barriers were crash-tested to determine their performance. A 12-in. timber curb, with steel splice plates connecting adjoining sections and steel pins driven into a gravel subbase, was used.

### 81-1314

#### Crash Tests of Small-Angle Sign Supports

K.C. Hahn

Engrg. Res. and Dev. Bureau, New York State Dept. of Transportation, Albany, NY, Rept. No. FHWA/NY/RR-80/81, 33 pp (June 1980)

PB80-213713

**Key Words:** Traffic sign structures, Dynamic tests, Collision research (automotive)

New York's small sign supports were crash tested to determine compliance with AASHTO criteria for basebending sign supports.

### 81-1315

#### The Optimal Mode in the Mode Approximation Technique

P.S. Symonds

Div. of Engrg., Brown Univ., Providence, RI 02912, Mechanics Res. Comm., 7 (1), pp 1-6 (1980) 2 figs, 7 refs

**Key Words:** Mode approximation technique, Pulse excitation

The paper proposes an addendum to a simple technique for obtaining approximate magnitudes of maximum permanent deflections and response times, in a structure subjected to pulse loading. This technique obtains an approximate solution in terms of mode form (separated variable) full solutions of the field equations, with initial amplitude of the velocity field chosen so as to minimize the initial value of a functional  $\Delta$  of the actual response velocity and the approximating mode solution,  $\Delta_0^{\min}$  representing the greatest difference between the two fields in a squared-integrated sense. Apart from other advantages, the least value of  $\Delta_0^{\min}$  was suggested as a means of identifying the particular mode, from a family of available mode solutions, which would provide the best approximation. The present note shows by a simple lumped-mass model that this criterion fails if unstable as well as stable modes are considered. A better criterion is here proposed, namely that the largest value of a lower bound on the root mean-square final deflection identifies the mode giving the best approximation. This lower bound is derived and illustrated together with other possible criteria.

### 81-1316

#### Nuclear Hardness Assurance for Aeronautical Systems

R.P. Patrick and J.M. Ferry

Strategic Air Command, U.S. Air Force, SAE Paper No. 801227, 20 pp, 7 figs, 16 refs

**Key Words:** Hardened installations, Nuclear weapons effects

This paper addresses nuclear hardness assurance as it relates to system acquisition, prerequisite efforts necessary for an affordable hardness assurance program, and the key aspects of the management of the program.

### 81-1317

#### Calculation of Ground Shock Motion Produced by Near Surface Airburst Explosions Using Cagniard Elastic Propagation Theory

J.R. Britt

Army Engineer Waterways, Experiment Station, Vicksburg, MS, 13 pp (June 1980)  
AD-A090 367/4

**Key Words:** Air blast, Ground motion, Ground shock, Shock wave propagation

The exact closed form integral solutions of Cagniard for the reflection and refraction of spherical waves in elastic solids were adapted and extended to model the ground shock propagation in a layered earth. In this formulation the particle motion is obtained as a sum of components propagated along rays or paths associated with distinct P and S wave arrivals. Calculations using the Cagniard procedure were used previously successfully by the author to predict the reflection of underwater explosion shock waves from the ocean bottom. The theoretical analysis and computer code development for the ground shock calculations were extensions of the bottom reflection study.

### 81-1318

#### Applications of Risk Analysis in Earthquake-Resistant Design

J. Lee

Ph.D. Thesis, Univ. of California, Berkeley, 170 pp (1980)  
UM 8029472

**Key Words:** Seismic design, Earthquake prediction, Ground motion, Optimum design

This dissertation proposes and develops a methodology for formulating and solving a class of problems in optimal earthquake-resistant design of structures. In particular, it deals with: uncertainty in the occurrence of destructive earthquakes in space and time; uncertainty in the characteristics of ground motion at a site; and uncertainty in statistical models, structural parameters and material strength.

### 81-1319

#### Earthquake Waves in a Random Medium

L. Chu, A. Askar, and A.S. Cakmak

Princeton Univ., Dept. of Civil Engrg., Princeton, NJ 08544, Intl. J. Numer. Anal. Methods Geomech., 5 (1), pp 79-96 (Jan-Mar 1981) 5 figs, 11 refs

**Key Words:** Earthquakes, Seismic waves, Elastic media, Viscoelastic media, Damping

Measurements are conducted with small samples in the laboratory and thus for all practical purposes the medium is macroscopically homogeneous. On the other hand, the uncertainties and the irregular changes in situ are macroscopic inhomogeneities. This work is an attempt to account for these stochastic changes in the elastic properties and density in a rational manner.

### 81-1320

#### Optimal Design of Localized Nonlinear Systems with Dual Performance Criteria under Earthquake Excitations

M.A. Bhatti

Ph.D. Thesis, Univ. of California, Berkeley, 98 pp (1980)  
UM 8029330

**Key Words:** Nonlinear systems, Seismic design, Minimax technique, Optimum design

This report presents a formulation for earthquake-resistant design of localized nonlinear systems. Based upon the current design criteria, two levels of performance constraints are imposed as follows. For small earthquakes which occur frequently, the structure is constrained to remain elastic with no structural damage.

### 81-1321

#### Fracture Effects in the Propagation of a Shock Wave through a Bulk Solid

W. Kosinski

Warsaw, Poland, Arch. Mechanics, 32 (3), pp 421-430 (1980) 18 refs

**Key Words:** Shock wave propagation, Cracked media, Discontinuity-containing media

The approach of nonlinear continuum mechanics is used in formulating three-dimensional stress-strain and internal state variable constitutive equations for a class of bulk solids. The internal state variable influences the generalized elastic modulus and describes the sensitivity of the rheological material to changes of the specific volume. A plane shock wave propagating through the material medium is analyzed. An effect of fracture characterized by the blow-up of the amplitude of the wave in finite time, is discussed. The conditions for such a behavior of the wave are formulated.

### 81-1322

#### Molecular Dynamic Shock Wave Studies in Solids - Fracture and Crack Propagation

A. Paskin

Queens College, Flushing, NY, Rept. No. ARO-14442-2-E, 4 pp (June 31, 1980)  
AD-A088 335/5

**Key Words:** Shock wave propagation, Crack propagation

The earlier computer simulations of shock waves in solids was completed. An equation of state for shock waves in

solids was developed and found to be an accurate description of shock wave properties. Computer simulation techniques were also used to study fracture and crack propagation in solids. The basic assumptions made in the usual continuum mechanics calculations were examined and found to be at best approximate.

### 81-1323

#### Transonic Shock Interaction with a Turbulent Boundary Layer on a Curved Wall

G.R. Inger and H. Sobieczky

Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, ASME Paper No. 79-WA/FE-13

**Key Words:** Shock wave propagation, Boundary layer damping, Walls

A detailed analysis is made of longitudinal surface curvature effects on the interaction of weak nearly normal oblique shocks with a nonseparating two-dimensional turbulent boundary layer. It is shown that the interactive viscous displacement effect on the local outer inviscid transonic flow completely eliminates the well-known singularity pertaining to purely inviscid flow on a curved wall; i.e., the interactive pressure field is regular behind the shock.

### 81-1324

#### Elastic, Finite Deflection and Strain Rate Effects in a Mode Approximation Technique for Plastic Deformation of Pulse Loaded Structures

P.S. Symonds

Brown Univ., Providence, RI, J. Mech. Engrg. Sci., 22 (4), pp 189-197 (Aug 1980) 10 figs, 13 refs

**Key Words:** Pulse excitation, Mode approximation technique, Explosion effects, Beams

A general scheme is proposed for including effects of elastic deformation, finite geometry changes, and strain rate sensitivity in a simple approximate scheme for estimating maximum transient and permanent deformations in structures subjected to load pulses of high intensity. The method is applied here to fully clamped beams of mild steel subjected to explosive loading. Comparisons are made between estimates from the present method and test results, as well as with estimates by various rigid-plastic methods and (to a limited extent) with results from numerical methods.

## VIBRATION EXCITATION

(Also see Nos. 1299, 1379)

### 81-1325

#### Non-Gaussian Closure for Random Vibration of Non-Linear Oscillators

S.H. Crandall

Massachusetts Inst. of Tech., Cambridge, MA 02139, Int'l. J. Nonlin. Mechanics, 15 (4/5), pp 303-313 (1980) 1 fig, 11 refs

**Key Words:** Nonlinear systems, Random excitation

An approximate method for determining estimates of stationary response statistics for a non-linear oscillator driven by wide-band random excitation is described. The differential equation of the oscillator is used to generate relations between unknown response statistics. These relations are then used to fix a corresponding number of unknown parameters in a non-Gaussian probability distribution for the response. The method is illustrated by application to the Duffing oscillator. Elementary methods for evaluating the necessary correlations between excitation and response are discussed in an Appendix.

### 81-1326

#### The Vibrational Response of the Rectangular Parallelepiped

E. Hill

Ph.D. Thesis, The Univ. of Oklahoma, 89 pp (1980) UM 8101512

**Key Words:** Rectangular bodies, Vibration response, Boundary condition effects

This work presents exact normal mode solutions for the forced vibrational response of the rectangular parallelepiped with three sets of boundary conditions: completely rigid-lubricated boundaries; two stress-free and four rigid-lubricated boundaries; and two elastically restrained and four rigid-lubricated boundaries. Both analytical and numerical verifications of these solutions are provided. Applications are discussed in the fields of acoustic emission non-destructive testing and the calibration of piezoelectric transducers.

### 81-1327

#### An Experimental Investigation of Low Frequency Self-Modulation of Incompressible Impinging Cavity Shear Layers

C.W. Knisely

Ph.D. Thesis, Lehigh Univ., 281 pp (1980)  
UM 8102505

**Key Words:** Self-excited vibrations, Vortex-induced excitation

Classically, investigations of self-sustaining oscillations of impinging flows have focused on the fundamental frequency; this experimental investigation of incompressible flow past a cavity reveals organized low frequency components having substantial amplitudes relative to that of the fundamental. These low frequency components are shown to be associated with the interaction of successive shear layer vortices with the downstream cavity corner. Vortices approach the corner at varying transverse locations resulting in varying degrees of severing of incident vortical structures. Organized patterns in the degree of severing of successive vortices are associated with low frequency components of the pressure fluctuation at impingement. This unsteady field at impingement modulates the upstream region of the shear layer near separation; in turn, the resultant velocity fluctuations are amplified in the free shear layer.

Dept. of Electrical Engrg., Indian Inst. of Tech., Kanpur 208016, India, J. Sound Vib., 73 (1), pp 73-78 (Nov 8, 1980) 2 figs, 5 refs

**Key Words:** Self-excited vibrations, Van der Pol oscillators, Vibration control, Perturbation theory

A perturbational analysis is presented of the effects of coupling and parametric forcing in two coupled van der Pol systems. The quenching of self-excited oscillation is obtained by the action of parametric forcing. It is further shown that at some threshold value of forcing amplitude the self-oscillation is suppressed. Simulation results are given to verify the analytical findings.

### 81-1328

#### Bifurcation of Periodic Motions in Two Weakly Coupled Van der Pol Oscillators

R.H. Rand and P.J. Holmes

Dept. of Theoretical and Appl. Mechanics, Cornell Univ., Ithaca, NY 14853, Intl. J. Nonlin. Mechanics, 15 (4/5), pp 387-399 (1980) 5 figs, 24 refs

**Key Words:** Periodic response, Van der Pol oscillators, Perturbation theory

A pair of weakly coupled van der Pol oscillators are studied and the bifurcations of phase-locked periodic motions which occur as the coupling coefficients are varied are investigated. Perturbation methods are used and their relation to the topological structure of solutions in the four dimensional phase space is discussed. While the problem is formulated for general linear coupling, the case of detuning plus diffusive coupling via displacement and velocity is discussed in more detail. It is shown that up to four phase-locked periodic motions can exist in this case.

### 81-1330

#### Non-Linear Vibrations of General Structures

J. Padovan

Dept. of Mech. Engrg., Univ. of Akron, Akron, OH 44325, J. Sound Vib., 72 (4), pp 427-441 (Oct 22, 1980) 10 figs, 27 refs

**Key Words:** Nonlinear vibration, Finite element technique, Perturbation theory

Based on the finite element and perturbation procedures, an analytical-numerical approach to non-linear vibrations is developed. In particular, the overall solution employs the finite element method to handle spatial dependencies while the constrained version of the perturbation procedure is used to treat the temporal behavior. Due to the generality of the method developed, any combination of structure and boundary restraints can be treated as well as the possibility of conservative and non-conservative situations wherein the system can have any number of frequency branches. Furthermore, the procedure is not restricted to excitations in the neighborhood of specific frequencies, but rather applies to the full range. To demonstrate the capabilities of the solution approach, the results of several numerical studies are included along with experimental verification.

### 81-1329

#### Quenching in a System of Coupled Van der Pol Oscillators

Y.P. Singh

### 81-1331

#### The Resonant Vibration of Homogeneous Non-Linear Systems

W. Szemplinska-Stupnicka

Inst. of Fundamental Technological Res., Polish Academy of Sciences, 00-049 Warsaw, Swietokrzyska 21, Poland, Intl. J. Nonlin. Mechanics, 15 (4/5), pp 407-415 (1980) 7 figs, 7 refs

**Key Words:** Nonlinear systems, Resonant response, Harmonic excitation

The paper presents some results on the resonant response of a two-degree-of-freedom nonlinear, "homogeneous" system of the order  $k = 3$ , subject to harmonic excitation. It has been shown that the resonant response is very close to the normal mode vibration, being a harmonic function of time in a relatively wide region of the frequency of excitation. The new type of jump phenomenon - the jump from one resonant state to the other - involving a sudden change of the amplitude and the mode shape of vibration were predicted theoretically and confirmed by the aid of an analog-computer.

### 81-1332

#### Dynamic Modal Estimation Using Instrumental Variables

H. Salzwedel

Aeronautical and Marine Systems Div., Systems Control, Inc., Palo Alto, CA, Rept. No. NASA-CR-152396; TR-6419-01, 66 pp (July 1980)  
N80-32777

**Key Words:** Mode shapes, Aircraft, Spacecraft, Off-shore structures

A method to determine the modes of dynamical systems is described. The inputs and outputs of a system are Fourier transformed and averaged to reduce the error level. An instrumental variable method that estimates modal parameters from multiple correlations between responses of single input, multiple output systems is applied to estimate aircraft, spacecraft, and off-shore platform modal parameters.

### 81-1333

#### A Test for Time Dependence of Multivariate Linear Systems

P.N. Nikiforuk and P.W. Davall

Univ. of Saskatchewan, Canada, ASME Paper No. 80-WA/DSC-30

**Key Words:** Linear systems, Frequency response

In this paper a test is derived for the time-dependence of multivariable linear systems based upon the conditional sampling distribution of the frequency response matrix given estimates of the input cospectrum matrix.

### 81-1334

#### On Integral Manifolds for Autonomous Systems with Slowly Modulated Motions

P.R. Sethna

Dept. of Aerospace Engrg. and Mechanics, Univ. of Minnesota, MN, Intl. J. Nonlin. Mechanics, 15 (4/5), pp 401-405 (1980) 8 refs

**Key Words:** Amplitude modulation, Nonlinear systems, Follower forces

Autonomous systems having slow amplitude modulated motions are studied. A theorem is proved which gives the existence and estimates of size of integral manifolds for such systems. The mathematical results are then applied to study a nonlinear system with follower forces.

## MECHANICAL PROPERTIES

### DAMPING

(Also see No. 1396)

### 81-1335

#### The Damping of Structural Vibration by Thin Gas Films

M.J.H. Fox and P.N. Whittom

Central Electricity Generating Board, Berkeley Nuclear Labs., Berkeley, Gloucestershire GL13 9BP, UK, J. Sound Vib., 73 (2), pp 279-295 (Nov 22, 1980) 5 figs, 1 table, 12 refs

**Key Words:** Vibration damping, Gases, Vibration absorbers (equipment)

A theoretical and experimental investigation of the processes by which thin layers of gas trapped between surfaces of a structure may contribute to damping of structural vibrations is described. Effects of gas compressibility, inertia and thermal conductivity are allowed for in the theory. Particular attention is given to the variation of damping with gas pressure and layer thickness. The aim of the investigation was to provide results of use in the design of vibration absorbers for use in pressurized gas environments, as well as to contribute to a better understanding of the behavior of pre-existing gas layers in structures.

### 81-1336

#### **The Analysis and Design of Constrained Layer Damping Treatments**

P.J. Torvik

Air Force Inst. of Tech., Wright-Patterson AFB, OH,  
Rept. No. AFIT-TR-80-4, 65 pp (July 1980)  
AD-A088 200/1

**Key Words:** Layered damping, Resonant response, Vibration control

A tutorial work in which the mechanisms by which large shear strain may be induced in a damping layer are explored. The parameters of the system which determine the effectiveness of constrained layer treatments are identified from analyses of several geometric configurations. Advances of the past two decades in the design and analysis of damping layers as a means of controlling the amplitude of resonant vibrations are reviewed.

### 81-1337

#### **Electronic Damping of Orthogonal Bending Modes in a Cylindrical Mast - Theory**

C.J. Swigert and R.L. Forward

Hughes Aircraft Co., Culver City, CA, J. Spacecraft Rockets, 18 (1), pp 5-10 (Jan/Feb 1981) 13 figs, 2 refs

**Key Words:** Vibration damping, Flexural vibration, Beams, Cylindrical beams

A theoretical model that describes the effect of electronic damping applied to the first two orthogonal bending modes of a cylindrical mast is presented. Computer predictions of the amplitude and phase response of the mast to excitation frequencies around the two closely spaced resonant modes for different levels of feedback damping are obtained. The analytical model predicts that, with only one damping circuit active and low levels of feedback, both modes are weakly damped. The theoretical predictions of the model agree in detail with the experimental results obtained in the previous paper.

### 81-1338

#### **Electronic Damping of Orthogonal Bending Modes in a Cylindrical Mast - Experiment**

R.L. Forward

Hughes Res. Labs., Malibu, CA, J. Spacecraft Rockets, 18 (1), pp 11-17 (Jan/Feb 1981) 12 figs, 4 refs

**Key Words:** Vibration damping, Flexural vibration, Beams, Cylindrical beams

Electronic damping was applied to two orthogonal bending modes in a cylindrical mast. The behavior of the experimental setup agrees remarkably well with the theoretical predictions of a mathematical model developed by C.J. Swigert in an accompanying paper.

### 81-1339

#### **Porcelain Enamel Material Testing Procedures to Determine the Damping Properties and the Results of Selected Materials**

D.M. Hopkins and M.L. Drake

Univ. of Dayton Res. Inst., Dayton, OH 45469, Rept. No. AFWAL-TR-80-4116, 155 pp (Sept 1980)

**Key Words:** Testing techniques, Material damping, Damping coefficients, Ceramics

This report contains a detailed discussion of methods and procedures used to define the vibration damping properties of high temperature (260°C to 780°C) damping materials. The work was done by the University of Dayton Research Institute, Dayton, Ohio in partial fulfillment of Air Force Contract Number F33615-76-C-5137 for the Materials Laboratory, Wright-Patterson Air Force Base, Ohio. The work described was conducted during the period January 1976 through December 1979.

### 81-1340

#### **Polymeric Material Testing Procedures to Determine Damping Properties and the Results of Selected Commercial Material**

M.L. Drake and G.E. Terborg

Univ. of Dayton Res. Inst., Dayton, OH 45469, Rept. No. AFWAL-TR-80-4093, 226 pp (July 1980)

**Key Words:** Testing techniques, Material damping, Damping characteristics, Polymers

This report contains a detailed discussion of the methods and procedures used to determine the damping properties of commercially available polymeric materials. The work was done by the University of Dayton Research Institute, Dayton, Ohio, in partial fulfillment of Air Force Contract Number F33615-76-C-5137 for the Materials Laboratory, Wright-Patterson Air Force Base, Ohio.

## FATIGUE

(Also see No. 1298)

**81-1341**

### Effect of Load History on Fatigue Life

J.T. Ryder

Rye Canyon Res. Lab., Lockheed-California Co., Burbank, CA, Rept. No. LR-29586, AFWAL-TR-80-4044, 261 pp (June 1980)

AD-A088 439/5

**Key Words:** Fatigue life, Layered materials

The primary objectives of this program are to: study in detail how mechanical loading parameters affect the fatigue life of graphite/epoxy laminates; determine the effects of environmental and geometrical perturbations on the effects studied in objective 1; and analyze the results in a manner such that an expanded foundation is laid for formulating fatigue life models based on knowledge of failure mechanisms. This report describes the analytical and experimental work undertaken in Task 1.

**81-1342**

### A Comparison of Fatigue Damage Detection in Carbon and Glass Fibre/Epoxy Composite Materials by Acoustic Emission

J. Holt and P.J. Worthington

Intl. J. Fatigue, 3 (1), pp 31-35 (Jan 1981) 10 figs, 5 refs

**Key Words:** Fiber composites, Composite materials, Fatigue life, Acoustic emission

Ring specimens of four fiber composite materials, two containing carbon fibers and two containing glass fibers have been monitored for acoustic emission during tension/tension fatigue cycling. It is shown that in the tests reported, the progressively increasing component of the activity can be related to the fatigue life. The distribution of events over the load cycle shows that a dominant part of this progressively increasing activity is associated with some stress independent process. Use of the appropriate part of the load cycle also offers the possibility of focussing on the events associated with the damage that leads to final failure.

**81-1343**

### Environmental Dynamic Fatigue Crack Propagation in High Density Polyethylene: An Empirical Modeling Approach

H.M. El-Hakeem and L.E. Culver

Intl. J. Fatigue, 3 (1), pp 3-8 (Jan 1981) 10 figs, 31 refs

**Key Words:** Fatigue life, Polymers, Crack propagation

Part of a program to study environmental dynamic fatigue crack propagation in engineering thermoplastics is presented. High density polyethylene has been studied in terms of its stress cracking properties under dynamic loading conditions in detergent. This work complements previous investigations on stress cracking in detergent under static loading. The stress cracking was found to vary according to loading conditions and in conclusion, a dependence of crack growth rate on test frequency, amplitude and level of stress intensity factor is reported. An empirical model describing environmental fatigue crack propagation is proposed which adequately represents the experimental results of high density polyethylene, Nylon 66 and which, it is suggested, may be suitable for use with other polymers.

**81-1344**

### Experimental Random Fatigue in Elastic-Plastic Range - Models of Significant Variables

T.C. Huang and V.K. Nagpal

Dept. of Engrg. Mechanics, Wisconsin Univ., Madison, WI, Rept. No. UW/RF-6, 28 pp (Sept 1979)

AD-A090 495/3

**Key Words:** Fatigue tests, Random excitation, Elastic-plastic properties, Variance analysis

In the previous study of first order models with 11 variables to predict fatigue life of materials in elastic-plastic range under random vibrations, 5 variables showed significant effects. In this report both first and second order models based on 5 significant variables have been developed. The tables of analysis of variance, and of the predicted lives together with residuals and 95% confidence intervals, are constructed for each model. These results contrast with those which are obtained by the principle of linear damage accumulation and cycle counting and involve several hundred percent error as a rule.

**81-1345**

### Experimental Random Fatigue in Elastic Range - Models of Significant Variables

T.C. Huang and V.K. Nagpal

Dept. of Engrg. Mechanics, Wisconsin Univ., Madison,

WI, Rept. No. UW/RF-4, 30 pp (July 1979)  
AD-A090 693/3

**Key Words:** Fatigue tests, Random excitation, Elastic properties, Variance analysis

In the previous study of first order models with 8 response variables to predict fatigue life in elastic range under random vibrations, 4 variables showed significant effects. In this part of the research both first and second order models of these 4 significant variables based on 10, 18, and 24 tests are developed. The tables of analysis of variance, and of predicted lives together with their residuals and 95% confidence intervals are constructed for each of the first and second order models.

#### 81-1346

#### **Experimental Random Fatigue in Elastic-Plastic Range - First Order Models**

T.C. Huang and V.K. Nagpal

Dept. of Engrg. Mechanics, Wisconsin Univ., Madison,  
WI, Rept. No. UW/RF-5, 33 pp (Aug 1979)  
AD-A090 694/1

**Key Words:** Fatigue tests, Random excitation, Elastic-plastic properties, Regression analysis

An experimental program, based on 11 probabilistic parameters and 3 experiment designs was conducted for 24 specimens for fatigue of materials in an elastic-plastic range under random vibrations. The magnitude levels of all probabilistic parameters are completed from the spectral moments and coded. By regressing the log of fatigue life on the corresponding coded parameters, the first-order regression models are developed.

#### 81-1347

#### **Experimental Random Fatigue in Elastic Range - First Order Models**

T.C. Huang and V.K. Nagpal

Dept. of Engrg. Mechanics, Wisconsin Univ., Madison,  
WI, Rept. No. UW/RF-3, 40 pp (June 1979)  
AD-A090 692/5

**Key Words:** Fatigue tests, Random excitation, Elastic properties, Regression analysis

An experiment program, based on 8 probabilistic parameters and 3 experiment designs, was conducted for 24 specimens

for the fatigue life of materials in elastic range under random vibrations. The magnitude levels of all probabilistic parameters for the response of every specimen were computed from its spectral moments and were coded. By regressing the log of fatigue life on coded probabilistic parameters the first order models to predict fatigue life were obtained.

#### 81-1348

#### **Ultrasonic and Acoustic Emission Detection of Fatigue Damage**

S.R. Buxbaum, C.L. Friant, S.E. Fick, and R.E. Green, Jr.

Dept. of Materials Science and Engrg., Johns Hopkins Univ., Baltimore, MD, Rept. No. AFOSR-TR-80-1069, 120 pp (July 1980)

AD-A090 799/8

**Key Words:** Fatigue life, Acoustic emission, Nondestructive tests, Aircraft

The primary purpose of the research was to optimize existing ultrasonic and acoustic emission techniques and to investigate new ones for early detection of fatigue damage in aluminum alloys used in aircraft construction. Ultrasonic attenuation measurements made simultaneously with fatigue tests on aluminum alloy bar, and sheet specimens gave warning of crack formation and imminent fracture much earlier than conventional ultrasonic methods. An ultrasonic pulse-echo system was used during fatigue cycling to record conventional A-scan waveforms as well as to monitor ultrasonic attenuation. In addition, acoustic emission signals were recorded simultaneously with the ultrasonic measurements on each test specimen using two different acoustic emission systems. The correlation of evidence of cumulative fatigue damage and acoustic emission data was approached by the use of long term true-rms averaging of the system output and frequency domain analysis of acoustic emission signals recorded at selected intervals throughout the test. The integrity of the data was verified by independent electronic testing of the instrumentation. Visual and in situ eddy current inspection, and optical and scanning electron microscopy were used to correlate acoustic emission and ultrasonic attenuation data to the physically deformed microstructure.

## **ELASTICITY AND PLASTICITY**

#### 81-1349

#### **On the Dynamic Shakedown Stability**

F. Auconi

Gruppo Studi e Ricerche - SNIA, Meccanica, 15 (2),  
pp 82-86 (June 1980) 8 refs

**Key Words:** Shakedown theorem, Elastoplastic properties

Starting from a Benvenuto's sufficient stability Criterion, in the elastic-plastic range, on the load paths which will systematically exclude elastic returns in the actual state, and adopting a suitable incremental formulation of the Ceradini's theorem on the dynamic shakedown, the dynamic shakedown stability property may be proven, if the comparison material is assumed absolutely stable.

## EXPERIMENTATION

### MEASUREMENT AND ANALYSIS

(Also see Nos. 1273, 1332)

#### 81-1350

##### An Introduction to Dynamic Photoelasticity

J.W. Dally

College of Engrg., Univ. of Rhode Island, Kingston,  
RI 02851, Exptl. Mechanics, 30 (12), pp 409-416  
(Dec 1980) 13 figs, 23 refs

**Key Words:** Photoelastic analysis, Wave propagation, Vibration response, Crack propagation, Impact response (mechanical)

The general area of elastodynamics is divided into four more limited topics including stress-wave propagation, vibration and impact, fracture propagation and quasi-static transients. The application of dynamic photoelasticity to each topic is discussed. Recording methods used in dynamic photoelasticity which are reviewed include the high-speed framing camera, the Cranz-Schardin system, Q-switched ruby lasers, and a stop-action strobe system. Advantages and disadvantages of each method of recording are covered. Analysis procedures used in interpreting the dynamic isochromatic-fringe patterns are described. Examples are illustrated where separation of the principal stresses is possible and a calibration method for determining the dynamic material-fringe value is reviewed. Finally, four applications of dynamic photoelasticity to problems arising in geophysics, fracture mechanics, flaw detection and mining are briefly reviewed to show the versatility of the dynamic photoelastic method.

#### 81-1351

##### A Simple Method for Converting Frequency Domain Aerodynamics to the Time Domain

E.H. Dowell

Langley Res. Ctr., NASA, Hampton, VA, Rept. No.  
NASA-TM-81844, L-13789, 42 pp (Oct 1980)  
N80-33358/6

**Key Words:** Aerodynamic characteristics, Frequency domain method, Time domain method

A simple, direct procedure was developed for converting frequency domain aerodynamics into indicial aerodynamics. The data required for aerodynamic forces in the frequency domain may be obtained from any available (linear) theory. The method retains flexibility for the analyst and is based upon the particular character of the frequency domain results. An evaluation of the method was made for incompressible, subsonic, and transonic two dimensional flows.

#### 81-1352

##### Measurement of Impulsive Noise with a Data Logging System

J. Jakobsen

Johs, Jorgensen A/S, Consulting Engineers, Teknikerbyen 5, DK-2830, Denmark, Appl. Acoust., 13 (6),  
pp 457-469 (Nov/Dec 1980) 5 figs, 4 tables, 4 refs

**Key Words:** Noise measurement, Measuring instruments, Traffic noise

A data logging system used for long-term noise measurements is described. The system's ability to measure impulsive noise correctly is analyzed and compared with that of other systems. It is concluded that the systems considered in the investigation are able to measure impulsive noise with an error not exceeding 1 dB, provided the crest factor of the noise is less than 30 dB.

#### 81-1353

##### Measurement of Tube/Tube Support Clearance via Induced Vibration Analysis

D.C. Barrett, T.D. Scharton, and C.C. Kidd

ANCO Engineers, Inc., SAE Paper No. 801127, 16  
pp, 4 figs, 1 ref

**Key Words:** Vibration probes, Nuclear reactor components, Nuclear power plants, Boilers

A number of nuclear power plant steam generators have been troubled with corrosion buildup between the tubes and supporting plates. A vibration type probe which traverses the interior of the tubes during plant shutdown has been developed to inspect the tube and support crevices. The probe incorporates a miniature electric vibrator and accelerometers to induce and measure tube motion at the support plate junctions. Laboratory investigation indicates that clearance gaps ranging from 1 to 30 mils can be accurately and rapidly measured even in the presence of tube misalignment and varied tube support conditions. The probe system is also suited to in-situ measurements of heat exchanger tube vibration characteristics.

#### **81-1354**

#### **Pump Vibration Analysis by Telephone**

K.W. Templin

Dynamics Research Advanced Engineering Facility, Byron Jackson Pump Div., Borg Warner Corp., Los Angeles, CA, Design News, 37 (2), pp 97-100 (Jan 19, 1981)

**Key Words:** Vibration analysis, Measuring instruments, Pumps

A vibration analysis system is described to which an FM converter was added giving the capability of recording field vibration data on a cassette tape with a small and easily portable music tape recorder. Since the signal constitutes frequency modulation rather than amplitude it is possible to transmit the signal by telephone. The frequency signal received is correct and precise, and transmission distance is no problem. A couple examples of pump motor vibration analyses are described.

#### **81-1355**

#### **Plate Instrumented Wheelsets for the Measurement of Wheel/Rail Forces**

W.I. Thompson, III

Transportation Systems Ctr., Cambridge, MA, Rept. No. DOT-TSC-FRA-80-58, FRA/ORD-80/58, 66 pp (Oct 1980)

PB81-116113

**Key Words:** Interaction: rail-wheel, Measuring instruments, Wheelsets

Strain gauge instrumented wheelsets are an important research tool in experimental rail vehicle testing. This report expounds the principle of operation of the instrumented

plate type of wheelset which is constructed by the scientifically exact application of strain gauges on the plate region of railroad wheels so that the wheelset is transformed into a sophisticated force transducer. An example of the application of the principles expounded is presented for a locomotive wheelset having wheels with S-shaped plate regions and 40-in. (1016-mm) diameters. The corresponding measurement system that utilizes such instrumented wheelsets is synopsized. This information is useful to railroads and other research groups interested in measuring wheel/rail forces.

#### **81-1356**

#### **Dynamic Airblast Simulator (DABS) Instrumentation Development, Phase II**

W.R. Edgel and N.P. Baum

Eric H. Wang Civil Engrg. Res. Facility, New Mexico Univ., Albuquerque, NM, Rept. No. AFWL-TR-79-155, 119 pp (June 1980)

AD-A090 531/5

**Key Words:** Nuclear explosions, Simulation, Measuring instrumentation

Development of explosives-driven nuclear blast simulators requires instrumentation for measurements to characterize blast flow. In a series of field tests with a large shock-tube-like dynamic air-blast simulator (DABS) blast flow characterization is attempted through measurements of parameters related to dynamic pressure. Doppler radar and infrared thermometry techniques are described toward determination of detonation product interface velocity. Blunt face drag body and acoustic techniques are implemented toward determination of flow Mach number. Other measurements include high stress and particle velocity in the walls of the explosives driver chamber using manganin sensors, conduction pins, and a mutual inductance particle velocimeter. Results of the measurement implementations indicate the soundness of the technical approaches for measurement techniques in the extremely hostile blast flow environment.

#### **DYNAMIC TESTS**

(Also see Nos. 1298, 1313, 1314, 1339, 1340)

#### **81-1357**

#### **Shake Tests for Electronic Assemblies**

W. Tustin

Tustin Inst. of Tech., Inc., Santa Barbara, CA, Mach. Des., 53 (4), pp 93-95 (Jan 22, 1981) 3 figs

**Key Words:** Electronic instrumentation, Instrumentation response, Testing techniques, Random excitation

Electronic equipment frequently must be subjected to vibration tests so that unreliable assemblies can be detected. Swept-frequency tests, commonly applied to electronic gear, have proved to be somewhat unreliable. Experience has revealed that flawed products are detected more reliably by random-frequency tests.

were compared to identical simulations performed with the TRANAL code and indicate relatively good agreement between all the STEALTH and TRANAL calculations. The differences that are seen can probably be attributed to: large (STEALTH) vs. small (TRANAL) strain formulation and/or grid discretization differences.

## DIAGNOSTICS

(Also see No. 1369)

### 81-1358

#### Acceleration/Vibration Combined Environment Activities. Interim Report

R.L. Shuman

Sandia National Labs., Albuquerque, NM, Rept. No. CONF-800574-3, Contract AC04-76DP00789, 26 pp (1980)

SAND-80-1433C

**Key Words:** Vibrators (machinery), Test equipment and instrumentation

The combining of two environments, i.e., linear acceleration and vibration, for use in laboratory testing to determine the damage to some mechanical devices when simultaneously subjected to these two environments, is discussed. The use of a Genisco centrifuge with an Unholtz-Dickie vibration machine mounted on it is described. Initial efforts at operating a shaker on the centrifuge have not been completely successful, so modifications to the system are being made.

### 81-1359

#### Nonlinear Soil-Structure Interaction Calculations Simulating the SIMQUAKE Experiment Using STEALTH 2D

H.T. Tang, R. Hofmann, G. Yee, and D.K. Vaughan  
Science Applications, Inc., San Leandro, CA, In:  
NASA Langley Res. Ctr. Res. in Nonlinear Struct.  
and Solid Mech., pp 47-66 (1980)  
N80-32760

**Key Words:** Interaction: soil-structures, Simulation, Computer programs

Transient, nonlinear soil-structure interaction simulations of an Electric Power Research Institute, SIMQUAKE experiment were performed using the large strain, time domain STEALTH 2D code and a cyclic, kinematically hardening cap soil model. Results from the STEALTH simulations

### 81-1360

#### Diagnosing Induction Motor Vibration

J.H. Maxwell

Union Carbide Corp., Taft, LA, Hydrocarbon Processing, 60 (1), pp 117-120 (Jan 1981) 10 figs, 1 table

**Key Words:** Diagnostic techniques, Motors, Induction motors

Motor vibration problems are unique because of the influences of magnetic fields. The phenomena required for understanding and diagnosing vibration problems magnetic and mechanically induced are described. Several examples are given.

### 81-1361

#### Microprocessors and Remote Machinery Evaluation

J.D. Halloran and G.K. Mruk

Joy Mfg. Co., Buffalo, NY, Hydrocarbon Processing, 60 (1), pp 105-107 (Jan 1981) 5 figs, 1 table

**Key Words:** Diagnostic techniques, Rotors, Machinery, Automated testing

The possibilities of remote and automatic evaluation of rotating machinery are illustrated by a description of an existing basic system. The major components of this remote evaluation system used to periodically pull data from four channels of vibration as measured by proximity probes are described and their operation is explained.

### 81-1362

#### A New Damage Detecting Method by Mechanical Impedance Measurements

K. Nezu and H. Kidoguchi

Faculty of Engrg., Gunma Univ., Kiryu, Japan, Bull. JSME, 23 (186), pp 2125-2131 (Dec 1980) 10 figs, 1 ref

**Key Words:** Diagnostic techniques, Mechanical impedance, Nondestructive testing, Crack detection

A new nondestructive test method using the mechanical impedance was developed for nondestructively detecting damages, such as a crack, flaw, etc. in the structural member. This method consists of comparing mechanical impedance measurements of a sound structure before use with those of the same structure in service. In order to verify the utility of the method, bending vibration tests were carried out on a clamped rectangular steel plate model with two parallel stiffeners, measuring its mechanical impedance in the course of cutting away one of the stiffeners gradually, which meant to simulate the growth of a crack in the root of the stiffener. Basic knowledges for judging the existence, size and location of a damage could be obtained from the model tests and the hardware as well as the software for a damage detecting equipment could be designed, based on the experience of the tests.

L.E. Roemer and C.S. Chen  
Electrical Engrg. Dept., The Univ. of Akron, Akron, OH 44325, J. Franklin Inst., 310 (3), pp 145-153 (Sept 1980) 10 figs, 7 refs

**Key Words:** Diagnostic techniques, Cables (ropes), Cepstrum analysis, Fast fourier transform, Maximum entropy method

The Cepstrum processing method has been used on power cables for determining regions of damage. The method consists of: observing the spectrum of an original broad band signal source, introducing the signal into the cable, computing the change in the observed spectrum (as a result of echos from regions of cable non-uniformity) when the signal is injected into the cable, and finally computing the power-spectrum of the change in observed spectrum. A limitation of this technique is the use of band-limiting spectrum analyzers. Their limited bandwidth reduces range resolution estimation when used with the Fast Fourier Transform (FFT) technique. The maximum entropy method (MEM) is a more useful spectral estimator for this measurement technique. Examples are presented which show a comparison of the FFT and MEM techniques applied to practical cables.

### 81-1363

#### **Dynamic Testing and Acoustic Analysis of Concrete Dams**

M.W. Dobbs, R.S. Keown, R.E. Cooper, Jr., K.D. Blakely, and P.A. Martinez  
ANCO Engineers, Inc., Santa Monica, CA, SAE Paper No. 801128, 16 pp, 11 figs, 2 tables, 13 refs

**Key Words:** Dams, Concretes, Diagnostic techniques, Acoustic emission

Forced vibration tests of Pacoima Dam were performed as part of a continuing research effort for dam integrity monitoring. The results of these tests are presented including measured resonant frequencies and response shapes, estimated modal damping ratios, and measured acoustic emission properties. The goal of this research is to develop a field portable test method for damage and integrity assessment of concrete dams. In this method, the dynamic properties and the acoustic emission properties of dams are monitored to detect and locate arch and foundation defects. Comparison of the dynamic properties obtained in the present tests to dynamic properties obtained in tests performed shortly after the 1971 San Fernando earthquake tentatively confirm that gross structural changes can be detected.

### BALANCING

(Also see No. 1227)

### 81-1365

#### **The Balancing of Flexible Rotors (Theoretical Relation of Each Balancing Method and Accuracies)**

T. Iwatsubo  
The Faculty of Engrg., Kobe Univ., Nada, Kobe, Japan, Bull. JSME, 23 (186), pp 2096-2103 (Dec 1980) 10 figs, 1 table, 11 refs

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**Key Words:** Rotors, Flexible rotors, Balancing techniques, Model balancing technique, Influence coefficient method, Least squares method

In this paper a balancing method for flexible rotors is systematically defined and the relation between a model balance and an influence coefficient method is described. Then the least square method, a kind of the influence coefficient method is discussed in detail, that is, on the balancing quality, performance index, weighting function and the relation between the weighting function and measuring errors of the influence coefficients.

### 81-1364

#### **Maximum Entropy Method Spectral Estimation Applied to Power Cable Diagnostics via Cepstrum Processing**

### 81-1366

#### **A Unified Approach to the Mass Balancing of Rotating Flexible Shafts**

M.S. Darlow

Ph.D. Thesis, The Univ. of Florida, 325 pp (1980)  
UM 8029051

**Key Words:** Balancing techniques, Flexible rotors, Rotors (machine elements), Shafts (machine elements)

Flexible rotor balancing is essential for the safe operation of many types of rotating machines. The existing flexible rotor balancing procedures may be divided into the classifications of modal and influence coefficient balancing, none of which have gained broad acceptance due to the inherent disadvantages of each method. In this study, a new flexible rotor balancing procedure which incorporates the advantages (and objectives) and eliminates the disadvantages of modal and influence coefficient balancing has been developed, implemented and verified. The analytical background for, and a discussion of the literature of, rotor balancing is presented to provide a basis for this study.

### 81-1367

#### **A Better Way to Balance Turbomachinery**

L. Fielding and R.E. Mondy

Ingersoll-Rand Co., Phillipsburg, NJ, Hydrocarbon Processing, 60 (1), pp 97-104 (Jan 1981) 10 figs, 6 tables, 7 refs

**Key Words:** Balancing techniques, Turbomachinery

A four-plane, two-speed single balance correction program is presented which can be used on a programmable calculator to predict balance corrections from field trial data. It can be used in field balancing.

## MONITORING

### 81-1368

#### **Frequency Dependence of Acoustic Resonances on Blockage Position in a Fast Reactor Subassembly Wrapper**

M. Antonopoulos-Domis

United Kingdom Atomic Energy Authority, AEE Winfrith, Dorchester, Dorset, UK, J. Sound Vib., 72 (4), pp 443-450 (Oct 22, 1980) 6 figs, 3 refs

**Key Words:** Monitoring techniques, Nuclear reactors, Resonant frequencies

Monitoring changes of the acoustic resonance frequencies in the subassemblies of sodium cooled fast reactors is a poten-

tial method for blockage detection. The dependence of the resonance frequencies on blockage position along the subassembly has been investigated experimentally and the results compared with model predictions.

### 81-1369

#### **TF41/A7-E Engine Monitoring System Implementation Experience**

L.R. Demott

Detroit Diesel Allison, GMC, Indianapolis, IN, SAE Paper No. 801222, 20 pp, 7 figs, 12 refs

**Key Words:** Monitoring techniques, Diagnostic techniques, Aircraft engines, Computer-aided techniques

The concept of utilizing computers to monitor and diagnose aircraft engine operating health is relatively recent. One of the first of these systems to be developed for the military environment was the Inflight Engine Condition Monitoring System (IECMS) developed for the US Navy A7-E Attack aircraft. This system has progressed through several stages of development and is currently operational in 2 Attack Squadrons. Continued system development is planned to expand capabilities and increase overall cost effectiveness.

### 81-1370

#### **TriStar Engine Monitoring in British Airways**

E.R. White

Special Projects, British Airways, SAE Paper No. 801224, 28 pp, 18 figs

**Key Words:** Monitoring techniques, Aircraft engines, Computer-aided techniques

This paper describes the system operated to monitor the RB211 engines in their three fleets of TriStars and the philosophy which led to its design and integration with the existing maintenance structure. It is regarded as a successful, cost-effective system, having its major benefits in the maintenance area, but also of considerable use in repair-shop, logistics, and engine management fields.

### 81-1371

#### **Acoustic Emission Techniques for In-Flight Structural Monitoring**

B. Parrish

Parrish & Hill, Norman, OK, SAE Paper No. 801211,  
8 pp, 6 refs

**Key Words:** Monitoring techniques, Acoustic emission, Aircraft, Fatigue life

Faced with high replacement costs for airframes, commercial and military users are attempting to keep their high-time aircraft in service. Assistance comes from the field of acoustic emission (AE), which provides a means of monitoring structural integrity in cases where fatigue damage may jeopardize basic airworthiness. Acoustic emission are the distinctive stress waves generated in solid materials during crack growth. These stress waves can be detected by sensitive transducers coupled to the material surface. Sensing of AE signatures provides the basis for a system which can continuously monitor structural integrity during flight and warn of impending failure.

## ANALYTICAL METHODS

(Also see Nos. 1328, 1334, 1395)

**81-1373**

### A Nonlinear Time Integration Method for Crash Impact Analysis

J.R. Rooker

Ph.D. Thesis, North Carolina State Univ. at Raleigh, 177 pp (1980)  
UM 8100818

**Key Words:** Integral equations, Crash research (aircraft), Collision research (automotive), Collision research (ships)

Eleven nonlinear, explicit, one-step integrators were derived using the Padé approximant method to determine their suitability for crash impact analysis. The stability and accuracy characteristics of these Padé integrators were investigated using several second order test equations which include linear and nonlinear scalar equations, and two and three degree of freedom linear equations. Energy growth during the solution of damped and undamped test equations was numerically monitored to determine the stability limits of the Padé integrators. A local truncation error analysis was used to investigate their accuracy.

## ANALYSIS AND DESIGN

### ANALOGS AND ANALOG COMPUTATION

**81-1372**

#### Dynamic Mixed Mode Fracture

A.S. Kobayashi and M. Ramulu

Dept. of Mech. Engrg., Washington Univ., Seattle, WA, Rept. No. TR-39, 15 pp (Aug 1980)  
AD-A088 287/8

**Key Words:** Crack propagation, Data processing, Photo-elastic analysis

A newly developed data reduction process was used to reevaluate dynamic photoelastic results and to extract dynamic stress intensity factors,  $K(I)_{dyn}$  and  $K(II)_{dyn}$ , associated with curved and branched cracks in fracturing Homalite-100 plates. A branching stress intensity factor approximately 5 times the fracture toughness was identified for this material. Moderate to severe crack curvings were associated with a  $K(I)_{dyn}$  and  $K(II)_{dyn}$  ratio as low as 0.06, but with positive remote stress component,  $\sigma_{\infty}$  (ox).

**81-1374**

### Nonlinear Mode Coupling of Surface Acoustic Waves on an Isotropic Solid

N. Kalayanasundaram

Dept. of Appl. Math., Indian Inst. of Science, Bangalore-560012, India, Intl. J. Engrg. Sci., 19 (3), pp 435-441 (1981) 3 figs, 6 refs

**Key Words:** Elastic waves, Modal analysis

The nonlinear mode coupling between two co-directional quasi-harmonic Rayleigh surface waves on an isotropic solid is analyzed using the method of multiple scales. This procedure yields a system of six semi-linear hyperbolic partial differential equations with the same principal part governing the slow variations in the (complex) amplitudes of the two fundamental, the two second harmonic and the two combination frequency waves at the second stage of the perturbation expansion. A numerical solution of these equations for excitation by monochromatic signals at two arbitrary frequencies, indicates that there is a continuous transfer of energy back and forth among the fundamental, second harmonic and combination frequency waves due to mode coupling. The mode coupling tends to be more pronounced as the frequencies of the interacting waves approach each other.

**81-1375****Dynamic Analysis of Structures by the Force Method**

A. Jaloh

Ph.D. Thesis, The Univ. of Arizona, 250 pp (1980)  
UM 8100301**Key Words:** Finite element technique, Finite displacement method

A force and formulation for the analysis of the dynamic behavior of a linearly elastic mechanical system with inertia is established. The method is developed, for the most part, in parallel with the finite element displacement method. It is shown that the displacements throughout the system are determined most appropriately from inertial considerations.

Ukr. SSR, Intl. J. Nonlin. Mechanics, 15 (4/5), pp 377-386 (1980) 11 refs**Key Words:** Nonlinear systems, Lyapunov's method, Perturbation theory

We present here some results obtained when developing the method of the Lyapunov function for the problems leading to the systems which contain a small positive parameter. Stating the Lyapunov-Caplygin problem for the standard systems and the proof of its solvability in case of a simple and perturbed Lyapunov function are given here; we obtained the stability conditions of solutions of the non-linear systems with a non-asymptotically stable generating system. The problem of constructing the Lyapunov functions by means of perturbations is solved in the present paper. An equation with damping of Maté is considered here as an example illustrating the technique of construction of the Lyapunov functions.

**81-1376****The Nature of the Solutions of Damped Linear Dynamic Systems**

D.J. Inman

Ph.D. Thesis, Michigan State Univ., 93 pp (1980)  
UM 8101117**Key Words:** Linear systems, Damped structures, Lumped parameter method, Continuous parameter method

An analysis of the qualitative nature of the solutions of viscously damped linear dynamic systems is presented. Both lumped parameter and distributed parameter systems are considered. Conditions illustrating whether or not a given system will oscillate were derived. These conditions can be checked without having to solve the governing differential equations. The conditions applied to the lumped parameter case are shown to imply certain closed form solutions for arbitrarily forced systems. Several examples are given illustrating how these conditions may be used to design a specified system so that it will either oscillate or not, as desired. The theory developed here is compared with previous results by other authors. In the case of distributed parameter theory, the results derived here are compared to specific problems from the literature. New information is provided about certain classes of damped beams and plates.

**81-1378****On the Method of Sections for Research on Certain Almost Periodic Solutions to Systems with Periodic Forces (Sur la Methode des Sections Pour la Recherche de Certaines Solutions Presque Periodiques de Systemes Forces Periodiquement)**

M. Jean

Laboratoire de Mecanique et d'Acoustique, CNRS, Marseille, 31, chemin Joseph-Aiguier, 13274 Marseille Cedex 2, France, Intl. J. Nonlin. Mechanics, 15 (4/5), pp 367-376 (1980) 1 fig, 6 refs  
(In French)**Key Words:** Periodic response, Differential equations

We consider an ordinary differential equation  $x(t) = F(t, x(t))$  where  $F$  is  $T$  periodic. The problem of finding almost periodic solutions of this equation can be viewed as the problem of finding the simple closed invariant curves by the Poincaré mapping. We deal with this last problem using a method similar to the cross section method for dynamical systems.

**81-1377****Development of the Lyapunov Functions Method in Non-Linear Mechanics**

Y.A. Mitropolsky and A.A. Martynyuk

Inst. of Mathematics, Academy of Sciences of the

**81-1379****Dynamic Analysis of Periodic Structures**

A.Y.-T. Leung

Dept. of Civil Engrg., Univ. of Hong Kong, Hong Kong, J. Sound Vib., 72 (4), pp 451-467 (Oct 22, 1980) 6 figs, 5 tables, 22 refs

**Key Words:** Periodic structures, Free vibration, Difference equations

The natural vibration analysis of a periodic structure with repeated identical substructures may be simplified by using some symmetrical properties of the substructure dynamic matrices, resulting in a set of linear difference equations in the displacements. These equations are readily solved for cyclic symmetric systems, simply supported systems and infinite systems. The order of the overall frequency equations is at most equal to one half of the total number of degrees of freedom retained for a single substructure regardless of the number of substructures in the system. With these natural modes, the system with general boundary conditions at end stations is analyzed by a fast converging method.

160 pp, 35 figs, 12 tables, Price \$85-DM, Summarized in: VDI Z., 122 (22), p 1044 (Nov 1980), Avail: VDI-Verlag GmbH, Postfach 1139, 4000 Düsseldorf, Germany  
(In German)

**Key Words:** Reduction methods, Component mode analysis, Condensation method, Finite element technique

Two reduction methods, the condensation technique and the component mode analysis technique, are described and their application to large structural dynamics problems using finite element technique is presented. The two methods, separately or in combination, enable to reduce the number of degrees of freedom of the system under investigation, significantly reducing the time required for the solution.

## MODELING TECHNIQUES

(Also see Nos. 1206, 1226)

### 81-1380

#### An Algorithm for Incorporating Subsystem Modes into Overall Dynamic System Models

D.L. Margolis

Dept. of Mech. Engrg., Univ. of California, Davis, CA 95616, J. Franklin Inst., 310 (2), pp 107-117 (Aug 1980) 5 figs, 8 refs

**Key Words:** Bond graph technique, Mathematical models

Bond graphs are used to construct finite mode representations of inherently distributed systems. These systems are, perhaps, only part of an overall dynamic system. The "causal" information provided by the bond graph permits the derivation of an automatable algorithm which produces the state equations as well as all output variables associated with the finite modes. The procedure requires only the a priori knowledge of modal masses, frequencies, and associated mode shapes for general boundary conditions of the distributed parts of the system. Thus, the algorithm is applicable to any multidimensional distributed system which is representable by normal modes.

## NONLINEAR ANALYSIS

(See Nos. 1331, 1387)

## NUMERICAL METHODS

### 81-1382

#### Dynamic Crack Propagation Analysis of the SEN Specimen by a Numerical Method

M. Peri

Univ. of Washington, Seattle, WA, ASME Paper No. 80-WA/PVP-2

**Key Words:** Crack propagation, Numerical analysis

Crack initiation and fast crack propagation in the SEN specimen are investigated within the two-dimensional linear elastic fracture mechanics confines. The influence of the initial crack length and the initial loading (bluntness) are pursued and the phenomenon of terminal velocity is studied. The analysis is performed using the SMF2D code, which is based upon the simultaneous employment of both a stationary and a moving coordinate system, thus providing a continuous and smooth crack extension.

### 81-1381

#### Reduction of Degrees of Freedom in Structural Dynamics Problems (Reduktion von Freiheitsgraden bei Strukturdynamik-Aufgaben)

H. Rohrle

Dornier GmbH, Friedrichshafen, Fortschritt-Berichte der VDI-Zeitschriften, Reihe 1, Nr. 72 (1980).

### 81-1383

#### Diffraction of an Antiplane Shear Wave by Two Coplanar Griffith Cracks in an Infinite Elastic Medium

S. Itou

Dept. of Mech. Engrg., Hachinohe Inst. of Tech., Hachinohe 031, Japan, *Intl. J. Solids Struc.*, 16 (12), pp 1147-1153 (1980) 3 figs, 3 tables, 8 refs

**Key Words:** Wave diffraction, Cracked media, Fourier transformation, Numerical analysis

The scattering of a time-harmonic antiplane shear wave by two parallel and coplanar Griffith cracks embedded in an infinite elastic medium is considered. The input wave normally impinges on the cracks. Fourier transformations are utilized to reduce the problem to two simultaneous integral equations which can be solved by the series expansion method. The dynamic stress intensity factors are numerically computed.

#### 81-1384

#### **A New Approach to Compute System Response with Multiple Support Response Spectra Input**

C.-W. Lin and F. Loceff

Westinghouse Electric Corp., Nuclear Technology Div., Pittsburgh, PA 15230, Nucl. Engrg. Des., 60 (3), pp 347-352 (Oct 1980) 3 tables, 7 refs

**Key Words:** Response spectra, Supports

A new approach is presented to allow the system response be computed realistically and taken into account the effect of phase relationship between the multiple support response spectra input.

#### 81-1385

#### **An Iterative Method for the Generation of Seismic Power Spectral Density Functions**

C. Sundararajan

EDS Nuclear, Inc., San Francisco, CA 94104, Nucl. Engrg. Des., 61 (1), pp 13-23 (Nov 1980) 4 figs, 4 tables, 14 refs

**Key Words:** Spectral energy distribution techniques, Random vibration, Seismic response, Iteration

The paper presents an iterative method for the generation of seismic power spectral density functions from specified response spectra. As an example, the power spectral density function that is consistent with a USNRC response spectrum is generated. Convergence and accuracy of the solution are studied via this example, and it is found that good results can be obtained in only a few iterations (as low as one iteration

in certain cases). Characteristics of the generated power spectral density function and the implications of assuming the earthquake motion to be a stationary process are also discussed.

## **OPTIMIZATION TECHNIQUES**

#### 81-1386

#### **Investigation of Vibration Reduction through Structural Optimization**

H.W. Hanson

Bell Helicopter Textron, Fort Worth, TX, Rept. No. BHT-699-099-122, USAAVRADCOM-TR-80-D-13, 96 pp (July 1980)

AD-A088 917/0

**Key Words:** Vibration control, Optimization, Vincent circle method, Forced response strain energy method, Stiffness coefficients

The purpose of this program was to investigate structural optimization techniques for vibration reduction. The results of a practical evaluation of two such techniques, the Vincent circle method and the forced response strain energy method, are discussed. Initial comparison studies of the two methods based on stiffness parameter variations were conducted using an elastic-line NASTRAN model of the AH-1G helicopter. The forced response strain energy method was then applied to a large complex built-up NASTRAN AH-1G model. This application provided useful comparative data identifying the structural elements considered to be the primary contributors to the response. Realistic structural stiffness changes in these elements were assessed to determine their effect on vibration reduction. The Vincent circle method was further evaluated for mass tuning, damping, and dynamic absorber parameters using the elastic-line model.

## **COMPUTER PROGRAMS**

(Also see Nos. 1193, 1228, 1359)

#### 81-1387

#### **Users Manual for GNATS2 (A Finite Element Computer Program for the General Nonlinear Analysis of Two-Dimensional Structures)**

M.L. Callabresi and M.L. Chiesa

Sandia National Labs., Albuquerque, NM, 107 pp (July 1980)

SAND-80-8225

**Key Words:** Computer programs, Finite element technique, Nonlinear theories, Two degree of freedom systems

**GNATS** is a system of three user-oriented finite element computer programs designed for the nonlinear analysis of axisymmetric and two-dimensional static structures. A preprocessor program, MESH2, provides the two-dimensional finite element mesh. The main program, GNATS, solves the nonlinear structural problem including the effects of large displacements, large strains, and elastic-plastic material behavior. A Lagrangian coordinate system is used in GNATS for describing the equilibrium configuration of the body. A postprocessor program, GPRINT, prints the selected values of displacements, stresses, and strains. The input data required for using MESH2, GNATS, and GPRINT for a nonlinear structural analysis is described. Dynamic dimensions are used for all arrays in these programs.

**Key Words:** Helicopters, Helicopter noise, Aerodynamic loads, Vibration response, Wind-induced excitation, Computer programs

The computer program for a comprehensive analytical model of rotorcraft aerodynamics and dynamics is described. This analysis is designed to calculate rotor performance, loads, and noise; the helicopter vibration and gust response; the flight dynamics and handling qualities; and the system aeroelastic stability. The analysis is a combination of structural, inertial, and aerodynamic models, that is applicable to a wide range of problems and a wide class of vehicles. The analysis is intended for use in the design, testing, and evaluation of rotors and rotorcraft, and to be a basis for further development of rotary wing theories. This report documents the computer program that implements the analysis.

### **81-1388**

#### **A Comprehensive Analytical Model of Rotorcraft Aerodynamics and Dynamics. Part II. User's Manual**

W. Johnson

Ames Res. Ctr., NASA, Moffett Field, CA, Rept. No. NASA-A-8101, NASA-TM-81183, 98 pp (July 1980) AD-A090 288/2

**Key Words:** Helicopters, Helicopter noise, Aerodynamic loads, Wind-induced excitation, Computer programs

The use of a comprehensive analytical model of rotorcraft aerodynamics and dynamics is described. This analysis is designed to calculate rotor performance, loads, and noise; the helicopter vibration and gust response; the flight dynamics and handling qualities; and the system aeroelastic stability. The analysis is a combination of structural, inertial, and aerodynamic models, that is applicable to a wide range of problems and a wide class of vehicles. The analysis is intended for use in the design, testing and evaluation of rotors and rotorcraft, and to be a basis for further development of rotary wing theories. This report describes the use of the computer program that implements the analysis.

### **81-1389**

#### **A Comprehensive Analytical Model of Rotorcraft Aerodynamics and Dynamics. Part III. Program Manual**

W. Johnson

Ames Res. Ctr., NASA, Moffett Field, CA, Rept. No. NASA-A-8102, NASA-TM-81184, 255 pp (June 1980)

AD-A090 289/0

### **81-1390**

#### **Aircraft Noise Prediction Program Validation**

B.N. Shivashankara

Boeing Commercial Airplane Co., Seattle, WA, Rept. No. NASA-CR-159333, D6-48727, 163 pp (Oct 1980)

N80-34219

**Key Words:** Computer programs, Aircraft noise, Noise prediction

A modular computer program (ANOPP) for predicting aircraft flyover and sideline noise was developed. A high quality flyover noise data base for aircraft that are representative of the U.S. commercial fleet was assembled. The accuracy of ANOPP with respect to the data base was determined. The data for source and propagation effects were analyzed and suggestions for improvements to the prediction methodology are given.

### **81-1391**

#### **A Computer Model for the Prediction of Factory Noise**

B.M. Shield

2, Montagu Rd., Datchet, Berk., UK, Appl. Acoust., 13 (6), pp 471-486 (Nov/Dec 1980) 9 figs, 4 refs

**Key Words:** Noise prediction, Industrial facilities, Computer programs

A computer program which calculates noise levels around a factory floor has been written. The collection of data for

input to the program, formulae used in the calculation of noise levels and output from the program are described. The program has been tested using data collected in a variety of workshops and factories. The results of two of these case studies are discussed, together with overall results for all cases considered, which show that the program can predict sound levels with a high degree of accuracy. An interactive version of the program which enables a user to see immediately how certain changes to the data will affect noise levels is also described.

#### 81-1392

#### Computer Program to Add NOISEMAP Grids of Different Spacings

H. Seidman

Bolt, Beranek and Newman, Inc., Canoga Park, CA,  
Rept. No. AMRL-TR-79-83, 30 pp (Apr 1980)  
AD-A088 205/0

**Key Words:** Computer programs, Aircraft noise, Sonic boom

Noise data for normal aircraft operations are usually calculated by the NOISEMAP computer program at grid points 1000 feet apart. Data from blast noise and supersonic aircraft are calculated at grid points several thousand feet apart. This report describes a computer program that was written to allow the two sets of data to be combined.

#### 81-1393

#### On the 3-D Non-Linear Analysis of Piping

L. Lazzari, M. Scala, and M. Agrone

AMN, via G. D'Annunzio 113, I-16121, Genova,  
Italy, Nucl. Engrg. Des., 61 (2), pp 209-222 (Nov  
1980) 11 figs, 34 refs

**Key Words:** Computer programs, Pipes (tubes), Pipe whip,  
Finite element technique

The computer program PAULA for the 3-D nonlinear analysis of piping is considered with particular reference to the finite elements library (straight pipe, elbow, T-joint, transition, restraint, non-linear superelement). The particular cases of the earthquake and pipe whip analysis are briefly discussed, in the latter case some attention is given to the relative merits of 2-D and 3-D analyses.

## GENERAL TOPICS

### CONFERENCE PROCEEDINGS

#### 81-1394

#### Rotordynamic Instability Problems in High-Performance Turbomachinery

Proc. of a workshop held at Texas A&M Univ.,  
College Station, TX, May 12-14, 1980. NASA Conference  
Publication 2133  
AD088701

**Key Words:** Rotors, Turbomachinery, Dynamic stability,  
Proceedings

This workshop was organized to address the general problem of rotordynamic instability. The workshop consisted of the following sessions: field experience with unstable turbomachinery; additional field experience with unstable machinery; diagnosis and data analysis; seal forces in turbomachinery; unstable motion of rotors in bearings; other mechanisms for rotor instabilities; control of rotor instabilities.

### TUTORIALS AND REVIEWS

#### 81-1395

#### Vibrations and Stability of Mechanical Systems: II

K. Huseyin

Dept. of Systems Design, Univ. of Waterloo, Waterloo,  
Ontario, Canada N2L 3G1, Shock Vib. Dig.,  
13 (1), pp 21-29 (Jan 1981) 69 refs

**Key Words:** Reviews, Linear theories, Nonlinear theories,  
Stability, Parametric excitation

This article describes developments in linear and nonlinear theories for studying the vibrational and stability behavior of autonomous systems under the influence of several independent parameters. Four classes of systems are identified for linear theories: conservative, pseudo-conservative, gyroscopic, and circulatory. Nonlinear theories involve both gradient and nongradient systems.

**81-1396**

**Vibration Control with Viscoelastic Materials - II**

B.C. Nakra

Mech. Engrg. Dept., Indian Inst. of Tech., Hauz Khas, New Delhi - 110029, India, Shock Vib. Dig., 13 (1), pp 17-20 (Jan 1981) 51 refs

**Key Words:** Reviews, Vibration control, Viscoelastic materials, Viscoelastic damping

This paper reviews investigations dealing with vibration control using viscoelastic materials. Specific topics include analysis of configurations, properties of the materials used, and applications.

**81-1397**

**Evaluation and Control of the Exhaust Noise of Reciprocating I.C. Engines**

M.L. Munjal

Dept. of Mech. Engrg., Indian Inst. of Science, Bangalore 560 012, India, Shock Vib. Dig., 13 (1), pp 5-14 (Jan 1981) 5 figs, 60 refs

**Key Words:** Reviews, Engine noise, Reciprocating engines, Noise reduction, Engine mufflers, Mufflers

The paper reviews recent advances in the analysis, design, and testing of exhaust mufflers for reciprocating internal combustion engines. An outline of specific areas needing further attention is given.

**CRITERIA, STANDARDS, AND SPECIFICATIONS**

(Also see No. 1186)

**81-1398**

**Review and Refinement of ATC 3-06 Tentative Seismic Provisions. Report of Technical Committee 2: Structural Design**

J.R. Harris

National Engrg. Lab., National Bureau of Standards, Washington, D.C., Rept. No. NBSIR-80-2111-2, 92 pp (Oct 1980)  
PB81-111759

**Key Words:** Regulations, Buildings, Seismic design

The Tentative Provisions for the Development of Seismic Regulations for Buildings were developed by the Applied Technology Council to present, in one comprehensive docu-

ment, current state-of-knowledge pertaining to seismic engineering of buildings.

**81-1399**

**Review and Refinement of ATC 3-06 Tentative Seismic Provisions. Report of Technical Committee 9: Regulatory Use**

J.H. Pielert and P.W. Cooke

National Engrg. Lab., National Bureau of Standards, Washington, D.C., Rept. No. NBSIR-80-2111-9, 71 pp (Oct 1980)  
PB81-111742

**Key Words:** Regulations, Buildings, Seismic design

The Tentative Provisions for the Development of Seismic Regulations for Buildings were developed by the Applied Technology Council to present, in one comprehensive document, current state-of-knowledge pertaining to seismic engineering of buildings. The Tentative Provisions are in the process of being assessed by the building community. This report is one of a series of reports that documents the deliberations of a group of professionals jointly selected by the building Seismic Safety Council and the National Bureau of Standards and charged with reviewing the Tentative Provisions prior to the conduct of trial designs. The report contains the recommendations and records of the committee charged with review of the regulatory implementation and enforcement aspects of the provisions. The committee made two recommendations for revisions to the Tentative Provisions and five additional recommendations concerning subsequent activities, such as the conduct of trial designs. These recommendations were made to the parent group, the Joint Committee on Review and Refinement, and their action on these recommendations is documented in a companion report.

**BIBLIOGRAPHIES**

**81-1400**

**Mechanical Impedance. January, 1974 - May, 1980 (Citations from the International Aerospace Abstracts Data Base)**

W.V. Sassi

New England Res. Application Ctr., Storrs, CT, Rept. No. NERACIAANT0432, 158 pp (Aug 1980)  
PB80-858277

**Key Words:** Bibliographies, Mechanical impedance, Spacecraft, Rotors (machine elements), Machine tools

Research studies and articles cited in this bibliography discuss the measurement, theory and reduction methods of mechanical impedance. Among the mechanical systems analyzed are assembled aerospace equipment, rotors, multi-resonance systems and machine tools.

**81-1401**

**Mechanical Impedance. June, 1970 - June 1980**  
**(Citations from the NTIS Data Base)**

W.V. Sassi

New England Res. Application Ctr., Storrs, CT,  
Rept. No. NERACUSNT0432, 78 pp (Aug 1980)  
PB80-858251

**Key Words:** Bibliographies, Mechanical impedance, Spacecraft, Rotors (machine elements), Machine tools

Research studies and articles cited in this bibliography discuss the measurement, theory and reduction methods of

mechanical impedance. Among the mechanical systems analyzed are assembled aerospace equipment, rotors, multi-resonance systems and machine tools.

**81-1402**

**Mechanical Impedance. June, 1970 - June, 1980**  
**(Citations from the Engineering Index Data Base)**

W.V. Sassi

New England Res. Application Ctr., Storrs, CT,  
Rept. No. NERACEI NT0432, 32 pp (Aug 1980)  
(sponsored in part by NTIS, Springfield, VA)  
PB80-858269

**Key Words:** Bibliographies, Mechanical impedance, Spacecraft, Rotors (machine elements), Machine tools

Research studies and articles cited in this bibliography discuss the measurement, theory and reduction methods of mechanical impedance. Among the mechanical systems analyzed are assembled aerospace equipment, rotors, multi-resonance systems and machine tools.

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## PERIODICALS SCANNED

PUBLICATION AND ADDRESS	ABBREVIATION	PUBLICATION AND ADDRESS	ABBREVIATION
<b>ACTA MECHANICA</b> Springer-Verlag New York, Inc. 175 Fifth Ave. New York, NY 10010	Acta Mech.	<b>JOURNAL OF ENGINEERING FOR POWER</b>	J. Engrg. Power, Trans. ASME
<b>ACUSTICA</b> S. Hirzel Verlag, Postfach 347 D-700 Stuttgart 1 W. Germany	Acustica	<b>JOURNAL OF ENGINEERING RESOURCES TECHNOLOGY</b>	J. Engrg. Resources Tech., Trans. ASME
<b>AERONAUTICAL JOURNAL</b> Royal Aeronautical Society 4 Hamilton Place London W1V 0BQ, UK	Aeronaut. J.	<b>JOURNAL OF LUBRICATION TECHNOLOGY</b>	J. Lubric. Tech., Trans. ASME
<b>AERONAUTICAL QUARTERLY</b> Royal Aeronautical Society 4 Hamilton Place London W1V 0BQ, UK	Aeronaut. Quart.	<b>JOURNAL OF MECHANICAL DESIGN</b>	J. Mech. Des., Trans. ASME
<b>AIAA JOURNAL</b> American Institute of Aeronautics and Astronautics 1290 Avenue of the Americas New York, NY 10019	AIAA J.	<b>JOURNAL OF PRESSURE VESSEL TECHNOLOGY</b>	J. Pressure Vessel Tech., Trans. ASME
<b>AMERICAN SOCIETY OF CIVIL ENGINEERS, PROCEEDINGS</b> ASCE United Engineering Center 345 East 47th St. New York, NY 10017		<b>APPLIED ACOUSTICS</b> Applied Science Publishers, Ltd. Ripple Road, Barking Essex, UK	Appl. Acoust.
<b>JOURNAL OF ENGINEERING MECHANICS DIVISION</b>	ASCE J. Engrg. Mechanics Div.	<b>ARCHIVES OF MECHANICS</b> (ARCHIWUM MECHANIKI STOSOWANEJ) Export and Import Enterprise Ruch UL, Wronia 23, Warsaw, Poland	Arch. Mechanics
<b>JOURNAL OF STRUCTURAL DIVISION</b>	ASCE J. Struc. Div.	<b>ASTRONAUTICS AND AERONAUTICS</b> AIAA EDP 1290 Avenue of the Americas New York, NY 10019	Astronaut. & Aeronaut.
<b>AMERICAN SOCIETY OF LUBRICATING ENGINEERS, TRANSACTIONS</b> Academic Press 111 Fifth Ave. New York, NY 10019	ASLE, Trans.	<b>AUTOMOBILTECHNISCHE ZEITSCHRIFT</b> Franckh'sche Verlagshandlung Abteilung Technik 7000 Stuttgart 1 Pfizerstrasse 5-7 W. Germany	Automobiltech. Z.
<b>AMERICAN SOCIETY OF MECHANICAL ENGINEERS, TRANSACTIONS</b> ASME United Engineering Center 345 East 47th St. New York, NY 10017		<b>AUTOMOTIVE ENGINEER (SAE)</b> Society of Automotive Engineers, Inc. 400 Commonwealth Drive Warrendale, PA 15096	Auto. Engr. (SAE)
<b>JOURNAL OF APPLIED MECHANICS</b>	J. Appl. Mechanics, Trans. ASME	<b>AUTOMOTIVE ENGINEER (UK)</b> P.O. Box 24, Northgate Ave. Bury St., Edmunds Suffolk IP21 GBW, UK	Auto. Engr. (UK)
<b>JOURNAL OF DYNAMIC SYSTEMS, MEASUREMENT AND CONTROL</b>	J. Dyn. Syst., Meas. and Control, Trans. ASME	<b>BALL BEARING JOURNAL (English Edition)</b> SKF (U.K.) Ltd. Luton, Bedfordshire LU3 1JF, UK	Ball Bearing J.
<b>JOURNAL OF ENGINEERING FOR INDUSTRY</b>	J. Engr. Indus., Trans. ASME	<b>BROWN BOVERI REVIEW</b> Brown Boveri and Co., Ltd. CH-5401, Baden, Switzerland	Brown Boveri Rev.
		<b>BULLETIN DE L'ACADEMIE POLONAISE DES SCIENCES, SERIES DES SCIENCES TECHNIQUES</b> Ara Polona-Ruch 7 Krakowskie Przedmiescie, Poland	Bull. Acad. Polon. Sci., Ser. Sci. Tech.

PUBLICATION AND ADDRESS	ABBREVIATION	PUBLICATION AND ADDRESS	ABBREVIATION
<b>BULLETIN OF JAPAN SOCIETY OF MECHANICAL ENGINEERS</b> Japan Society of Mechanical Engineers Sanjinin Hokusei Bldg. H-9 Yoyogi 2-chome Shibuya-ku Tokyo 151, Japan	Bull. JSME	<b>HEATING/PIPEING/AIR CONDITIONING</b> Circulation Dept. 614 Superior Ave. West Cleveland, OH 44113	Heating/ Piping/ Air Cond.
<b>BULLETIN OF SEISMOLOGICAL SOCIETY OF AMERICA</b> Bruce A. Bolt Box 826 Berkeley, CA 94705	Bull. Seismol. Soc. Amer.	<b>HYDRAULICS AND PNEUMATICS</b> Penton/IPC, Inc. 614 Superior Ave. West Cleveland, OH 44113	Hydraulics & Pneumatics
<b>CIVIL ENGINEERING (NEW YORK)</b> ASCE United Engineering Center 345 E. 47th St. New York, NY 10017	Civ. Engr. (N.Y.)	<b>HYDROCARBON PROCESSING</b> Gulf Publishing Co. Box 2608 Houston, TX 77001	Hydrocarbon Processing
<b>CLOSED LOOP</b> MTS Systems Corp. P.O. Box 24012 Minneapolis, MN 55474	Closed Loop	<b>IBM JOURNAL OF RESEARCH AND DEVELOPMENT</b> International Business Machines Corp. Armonk, NY 10504	IBM J. Res. Dev.
<b>COMPUTERS AND STRUCTURES</b> Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Computers Struc.	<b>INGENIEUR-ARCHIV</b> Springer-Verlag New York, Inc. 175 Fifth Ave. New York, NY 10010	Ing. Arch.
<b>DESIGN ENGINEERING</b> Berkshire Common Pittsfield, MA 02101	Des. Engng.	<b>INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS</b> IEEE United Engineering Center 345 East 47th St. New York, NY 10017	IEEE
<b>DESIGN NEWS</b> Cahners Publishing Co., Inc. 221 Columbus Ave. Boston, MA 02116	Des. News	<b>INSTITUTION OF MECHANICAL ENGINEERS, (LONDON), PROCEEDINGS</b> Institution of Mechanical Engineers 1 Birdcage Walk, Westminster, London SW1, UK	IMechE Proc.
<b>DIESEL AND GAS TURBINE PROGRESS</b> Diesel Engines, Inc. P.O. Box 7406 Milwaukee, WI 53213	Diesel Gas Turbine Prog.	<b>INSTRUMENT SOCIETY OF AMERICA, TRANSACTIONS</b> Instrument Society of America 400 Stanwix St. Pittsburgh, PA 15222	ISA Trans.
<b>ENGINEERING MATERIALS AND DESIGN</b> IPC Industrial Press Ltd. 33-40 Bowling Green Lane London EC1R, UK	Engrg. Mtl. Des.	<b>INSTRUMENTATION TECHNOLOGY</b> Instrument Society of America 67 Alexander Drive P.O. Box 12277 Research Triangle Park, NC 27709	InTech.
<b>ENGINEERING STRUCTURES</b> IPC Science and Technology Press Ltd. Westbury House P.O. Box 68, Bury Street Guildford, Surrey GU2 5BH, UK	Engrg. Struc.	<b>INTERNATIONAL JOURNAL OF CONTROL</b> Taylor and Francis Ltd. 10-14 Macklin St. London WC2B 5NF, UK	Intl. J. Control
<b>EXPERIMENTAL MECHANICS</b> Society for Experimental Stress Analysis 21 Bridge Sq., P.O. Box 277 Westport, CT 06880	Exptl. Mechanics	<b>INTERNATIONAL JOURNAL OF EARTHQUAKE ENGINEERING AND STRUCTURAL DYNAMICS</b> John Wiley and Sons, Ltd. 650 Third Ave. New York, NY 10016	Intl. J. Earthquake Engrg. Struc. Dynam.
<b>FEINWERK U. MESSTECHNIK</b> Cari Hanser GmbH & Co. D-800 Munchen 86 Postfach 860420 Fed. Rep. Germany	Feinwerk u. Messtechnik	<b>INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES</b> Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Engrg. Sci.
<b>FORSCHUNG IM INGENIEURWESEN</b> Verein Deutscher Ingenieur, GmbH Postfach 1139 Graf-Recke Str. 84 4 Dusseldorf 1 W. Germany	Forsch. In. genieurweesen		

PUBLICATION AND ADDRESS	ABBREVIATION	PUBLICATION AND ADDRESS	ABBREVIATION
<b>INTERNATIONAL JOURNAL OF FATIGUE</b> IPI Science and Technology Press Ltd. P.O. Box 63, Westbury House, Bury Street Guildford, Surrey, England GU2 5BH	Intl. J. Fatigue	<b>JOURNAL OF ENGINEERING MATHEMATICS</b> Academic Press 198 Ash Street Reading, MA 01867	J. Engr. Math.
<b>INTERNATIONAL JOURNAL OF MACHINE TOOL DESIGN AND RESEARCH</b> Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Mach. Tool Des. Res.	<b>JOURNAL OF ENVIRONMENTAL SCIENCES</b> Institute of Environmental Sciences 940 E. Northwest Highway Mt. Prospect, IL 60056	J. Environ. Sci.
<b>INTERNATIONAL JOURNAL OF MECHANICAL SCIENCES</b> Pergamon Press, Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Mech. Sci.	<b>JOURNAL OF FLUID MECHANICS</b> Cambridge University Press 32 East 57th St. New York, NY 10022	J. Fluid Mechanics
<b>INTERNATIONAL JOURNAL OF NONLINEAR MECHANICS</b> Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Nonlin. Mechanics	<b>JOURNAL OF THE FRANKLIN INSTITUTE</b> Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	J. Franklin Inst.
<b>INTERNATIONAL JOURNAL FOR NUMERICAL METHODS IN ENGINEERING</b> John Wiley and Sons, Ltd. 605 Third Ave. New York, NY 10016	Intl. J. Numer. Methods Engrg.	<b>JOURNAL OF HYDRONAUTICS</b> American Institute of Aeronautics and Astronautics 1290 Avenue of the Americas New York, NY 10019	J. Hydro- nautics
<b>INTERNATIONAL JOURNAL FOR NUMERICAL AND ANALYTICAL METHODS IN GEOMECHANICS</b> John Wiley and Sons, Ltd. Baffins Lane Chichester, Sussex, UK	Intl. J. Numer. Anal. Methods Geomech.	<b>JOURNAL OF THE INSTITUTE OF ENGINEERS, AUSTRALIA</b> Science House, 157 Gloucester Sydney, Australia 2000	J. Inst. Engr., Austral.
<b>INTERNATIONAL JOURNAL OF SOLIDS AND STRUCTURES</b> Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Solids Struc.	<b>JOURNAL DE MECANIQUE</b> Gauthier-Villars C.D.R. - Centrale des Revues B.P. No. 119, 93104 Montreuil Cedex-France	J. de mecanique
<b>INTERNATIONAL JOURNAL OF VEHICLE DESIGN</b> The International Assoc. of Vehicle Design The Open University, Walton Hall Milton Keynes MK7 6AA, UK	Intl. J. Vehicle Des.	<b>JOURNAL OF MECHANICAL ENGINEERING SCIENCE</b> Institution of Mechanical Engineers 1 Birdcage Walk, Westminster London SW1 H9, UK	J. Mech. Engrg. Sci.
<b>ISRAEL JOURNAL OF TECHNOLOGY</b> Weizmann Science Press of Israel Box 801 Jerusalem, Israel	Israel J. Tech.	<b>JOURNAL OF THE MECHANICS AND PHYSICS OF SOLIDS</b> Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	J. Mechanics Phys. Solids
<b>JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA</b> American Institute of Physics 335 E. 45th St. New York, NY 10016	J. Acoust. Soc. Amer.	<b>JOURNAL OF PETROLEUM TECHNOLOGY</b> Society of Petroleum Engineers 6200 N. Central Expressway Dallas, TX 75206	J. Pet. Tech.
<b>JOURNAL OF AIRCRAFT</b> American Institute of Aeronautics and Astronautics 1290 Avenue of the Americas New York, NY 10019	J. Aircraft	<b>JOURNAL OF PHYSICS: E SCIENTIFIC INSTRUMENTS</b> American Institute of Physics 335 East 45th St. New York, NY 10017	J. Phys. E: Sci. Instrum.
<b>JOURNAL OF THE AMERICAN HELICOPTER SOCIETY</b> American Helicopter Society, Inc. 30 East 42nd St. New York, NY 10017	J. Amer. Helicopter Soc.	<b>JOURNAL OF SHIP RESEARCH</b> Society of Naval Architects and Marine Engineers 20th and Northhampton Sts. Easton, PA 18042	J. Ship Res.
		<b>JOURNAL OF SOUND AND VIBRATION</b> Academic Press 111 Fifth Ave. New York, NY 10019	J. Sound Vib.

PUBLICATION AND ADDRESS	ABBREVIATION	PUBLICATION AND ADDRESS	ABBREVIATION
JOURNAL OF SPACECRAFT AND ROCKETS American Institute of Aeronautics and Astronautics 1290 Avenue of the Americas New York, NY 10019	J. Spacecraft Rockets	NOISE AND VIBRATION CONTROL Trade and Technical Press Ltd. Crown House, Morden Surrey SM4 5EW, UK	Noise Vib. Control
JOURNAL OF TESTING AND EVALUATION (ASTM) American Society for Testing and Materials 1916 Race St. Philadelphia, PA 19103	J. Test Eval. (ASTM)	NOISE CONTROL ENGINEERING P.O. Box 3206, Arlington Branch Poughkeepsie, NY 12603	Noise Control Engrg.
KONSTRUKTION Spring Verlag 3133 Connecticut Ave., N.W. Suite 712 Washington, D.C. 20008	Konstruktion	NORTHEAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS, TRANSACTIONS Bolbec Hall Newcastle upon Tyne 1, UK	NE Coast Instn. Engrs. Shipbldrs., Trans.
LUBRICATION ENGINEERING American Society of Lubrication Engineers 838 Buse Highway Park Ridge, IL 60068	Lubric. Engrg.	NUCLEAR ENGINEERING AND DESIGN North Holland Publishing Co. P.O. Box 3489 Amsterdam, The Netherlands	Nucl. Engrg. Des.
MACHINE DESIGN Penton Publishing Co. Penton Bldg. Cleveland, OH 44113	Mach. Des.	OIL AND GAS JOURNAL The Petroleum Publishing Co. 211 S. Cheyenne Tulsa, OK 74101	Oil Gas J.
MASCHINENBAUTECHNIK VEB Verlag Technik Oranienburger Str. 13/14 102 Berlin, E. Germany	Maschinen- bautechnik	PACKAGE ENGINEERING 5 S. Wabash Ave. Chicago, IL 60603	Package Engrg.
MECCANICA Pergamon Press, Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Meccanica	PLANT ENGINEERING 1301 S. Grove Avenue Barrington, IL 60010	Plant Engrg.
MECHANICAL ENGINEERING American Society of Mechanical Engineers 345 East 45th St. New York, NY 10017	Mech. Engrg.	POWER P.O. Box 521 Hightstown, NJ 08520	Power
MECHANICS RESEARCH AND COMMUNICATIONS Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Mechanics Res. Comm.	POWER TRANSMISSION DESIGN Industrial Publishing Co. Division of Pittway Corp. 812 Huron Rd. Cleveland, OH 44118	Power Transm. Des.
MECHANISM AND MACHINE THEORY Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Mech. Mach. Theory	QUARTERLY JOURNAL OF MECHANICS AND APPLIED MATHEMATICS Wm. Dawson & Sons, Ltd. Cannon House Folkestone, Kent, UK	Quart. J. Mechanics Appl. Math.
MEMOIRES OF THE FACULTY OF ENGINEERING, KYOTO UNIVERSITY Kyoto University Kyoto, Japan	Mem. Fac. Engrg. Kyoto Univ.	REVUE ROUMAINE DES SCIENCES TECHNIQUES, SERIE DE MECANIQUE APPLIQUEE Editions De L'Academie De La Republique Socialiste de Roumanie 3 Eis Str., Gutenberg, Bucurest, Romania	Rev. Roumaine Sci. Tech., Mecanique Appl.
MTZ MOTORTECHNISCHE ZEITSCHRIFT Franckh'sche Verlagshandlung Pfizerstrasse 5-7 7000 Stuttgart 1 W. Germany	MTZ Motor- tech. Z.	REVIEW OF SCIENTIFIC INSTRUMENTS American Institute of Physics 335 East 45th St. New York, NY 10017	Rev. Scientific Instr.
NAVAL ENGINEERS JOURNAL American Society of Naval Engineers, Inc. Suite 507, Continental Bldg. 1012 - 14th St., N.W. Washington, D.C. 20005	Naval Engr. J.	SAE PREPRINTS Society of Automotive Engineers Two Pennsylvania Plaza New York, NY 10001	SAE Prepr.
		SIAM JOURNAL ON APPLIED MATHEMATICS Society for Industrial and Applied Mathematics 33 S. 17th St. Philadelphia, PA 19103	SIAM J. Appl. Math.

PUBLICATION AND ADDRESS	ABBREVIATION	PUBLICATION AND ADDRESS	ABBREVIATION
SIAM JOURNAL ON NUMERICAL ANALYSIS Society for Industrial and Applied Mathematics 32 S. 17th St. Philadelphia, PA 19103	SIAM J. Numer. Anal.	VDI FORSCHUNGSSHEFT Verein Deutscher Ingenieur GmbH Postfach 1131, Graf-Kecke Str. 84 4 Düsseldorf 1, Germany	VDI Forsch.
STROJNICKY ČASOPIS Red. Strojnickeno Časopisu ČSAV A SAV USTAV MECHANIKY STROJOV SAV Bratislava-Patronka, Dubrovka cesta, ČSSR Czechoslovakia	Strojnický Časopis	VEHICLE SYSTEMS DYNAMICS Swets and Zeitlinger N.V. 347 B. Hereweg Lisse, The Netherlands	Vehicle Syst. Dyn.
S/V, SOUND AND VIBRATION Acoustic Publications, Inc. 27101 E. Oviat Rd. Bay Village, OH 44140	S/V, Sound Vib.	VIBROTECHNIKA Kauno Polytechnikos Institutas 2 Donelaičio g-ve 17 23300 Kaunas Lithuanian SSR	Vibro- technika
TECHNISCHES MESSEN - ATM R. Oldenburg Verlag GmbH Rothenheimer Str. 145 8 München 80, W. Germany	Techn. Messen-ATM	WAVE MOTION North Holland Publishing Co. P.O. Box 211 1000 AE Amsterdam The Netherlands	Wave Motion
TEST 61 Monmouth Road Oakhurst, NJ 07756	Test	WEAR Elsevier Sequoia S.A. P.O. Box 651 1001 Lausanne 1, Switzerland	Wear
TRIBOLOGY INTERNATIONAL IPC Science and Technology Press Ltd. Westbury House P.O. Box 63, Bury Street Guildford, Surrey GU2 5BH, UK	Tribology Intl.	ZEITSCHRIFT FÜR ANGEWANDTE MATHEMATIK UND MECHANIK Akademie Verlag GmbH Liepäziger Str. 3-4 108 Berlin, Germany	Z. angew. Math. Mech.
TURBOMACHINERY INTERNATIONAL Turbomachinery Publications, Inc. 22 South Smith St. Norwalk, CT 06855	Turbomach. Intl.	ZEITSCHRIFT FÜR FLUGWISSENSCHAFTEN DFVLR D-3300 Braunschweig Flughafen, Postfach 3267 W. Germany	Z. Flugwiss
VDI ZEITSCHRIFT Verein Deutscher Ingenieur GmbH Postfach 1131, Graf-Kecke Str. 84 4 Düsseldorf 1, Germany	VDI Z.		

## SECONDARY PUBLICATIONS SCANNED

GOVERNMENT REPORTS ANNOUNCEMENTS & INDEX NTIS U.S. Dept. of Commerce Springfield, VA 22161	GRA	DISSERTATION ABSTRACTS INTERNATIONAL University Microfilms Ann Arbor, MI 48106	DA
SCIENTIFIC AND TECHNICAL AEROSPACE REPORTS Superintendent of Documents U.S. Government Printing Office Washington, D.C. 20402	STAR		

## ANNUAL PROCEEDINGS SCANNED

INSTITUTE OF ENVIRONMENTAL SCIENCES, ANNUAL PROCEEDINGS Institute of Environmental Sciences 940 E. Northwest Highway Mt. Prospect, IL 60056	Inst. Environ. Sci., Proc.	THE SHOCK AND VIBRATION BULLETIN, UNITED STATES NAVAL RESEARCH LABORATORIES, ANNUAL PROCEEDINGS Shock and Vibration Information Center Naval Research Lab., Code 5804 Washington, D.C. 20375	Shock Vib. Bull., U.S. Naval Res. Lab., Proc.
TURBOMACHINERY SYMPOSIUM Gas Turbine Lab. Texas A&M University College Station, Texas	Turbomach. Symp.		

# CALENDAR

## JUNE 1981

8-10 NOISE-CON 81 [Institute of Noise Control Engineering and the School of Engineering, North Carolina State University] Raleigh, North Carolina (*Dr. Larry Royster, Program Chairman, Center for Acoustical Studies, Dept. of Mechanical & Aerospace Engr., North Carolina State University, Raleigh, NC 27650*)

10-12 CLEO '81 - Conference on Lasers and Electro-Optics [IEEE and OSA] Washington, D.C. (*Optical Society of America, 1816 Jefferson Place N.W., Washington, D.C. 20036*)

22-24 Applied Mechanics Conference [ASME] Boulder, CO (*ASME Hq.*)

## SEPTEMBER 1981

1-4 Joint Meeting of the British Society for Strain Measurement and the Society for Experimental Stress Analysis [B.S.S.M. and SESA] Edinburgh University, Scotland (*C. McCalvey, Administration Officer, B.S.S.M., 281 Heaton Road, Newcastle upon Tyne, NE6 50B, UK*)

7-11 Applied Modelling and Simulation Conference and Exhibition [I.A.S.T.E.D. and A.M.S.E.] Lyon, France (*A.M.S.E., 16, Avenue de Grande Blanche, 69160 Tassin-La-Demi-Lune, France*)

20-23 Design Engineering Technical Conference [ASME] Hartford, CT (*ASME Hq.*)

28-30 Specialists Meeting on "Dynamic Environmental Qualification Techniques" [AGARD Structures and Materials Panel] Noordwijkerhout, The Netherlands (*Dr. James J. Olsen, Structures and Dynamics Division, Air Force Wright Aeronautical Laboratories/FIB, Wright Patterson Air Force Base, OH 45433*)

30-Oct 2 International Congress on Recent Developments in Acoustic Intensity Measurement [CETIM] Senlis, France (*Dr. M. Bockhoff, Centre Technique des Industries Mecaniques, Boite Postale 67, F-60304, Senlis, France*)

## OCTOBER 1981

4-7 International Lubrication Conference [ASME - ASLE] New Orleans, LA (*ASME Hq.*)

5-8 SAE Aerospace Congress and Exposition [SAE] Anaheim, CA (*Roy W. Mustain, Rockwell Space Systems Group, AB 97, 12214 S. Lakewood Blvd., Downey, CA 90241*)

11-15 Fall Meeting of the Society for Experimental Stress Analysis [SESA] Keystone Resort, Keystone CO (*SESA, P.O. Box 277, Saugatuck Station, Westport, CT 06880*)

19-22 Intl. Optimum Structural Design Symp. [U.S. Office of Naval Research and Univ. of Arizona] Tucson, AZ (*Dr. Erdal Atrek, Dept. of Civil Engr., Bldg. No. 72, Univ. of Arizona, Tucson AZ 85721*)

21-23 34th Mechanical Failures Prevention Group Symp. [National Bureau of Standards] Gaithersburg, MD (*J.E. Stern, Trident Engineering Associates, 1507 Amherst Rd., Hyattsville, MD 20783 - (301) 422-9506*)

27-29 52nd Shock and Vibration Symposium [Shock and Vibration Information Center, Washington, D.C.] New Orleans, Louisiana (*Henry C. Pusey, Director, SVIC, Naval Research Lab., Code 5804, Washington, D.C. 20375*)

Eastern Design Engineering Show [ASME] New York, New York (*ASME Hq.*)

## NOVEMBER 1981

15-20 ASME Winter Annual Meeting [ASME] Washington, D.C. (*ASME Hq.*)

17-19 Technical Diagnostics Symposium [IMEKO Technical Committee on Technical Diagnostics] London, England (*Institute of Measurement and Control, 20 Peel Street, London W8 7PD, England*)

30-Dec 4 Acoustical Society of America, Fall Meeting [ASA] Miami Beach, FL (*ASA Hq.*)

## DECEMBER 1981

1-3 10th Turbomachinery Symposium [Texas A&M University] Houston, Texas (*Peter E. Jenkins, Director, Turbomachinery Laboratories, Dept. of Mechanical Engineering, Texas A&M University, College Station, TX 77843 - (713) 845-7417*)

8-10 Western Design Engineering Show [ASME] Anaheim, CA (*ASME Hq.*)

**CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS**

AFIPS:	American Federation of Information Processing Societies 210 Summit Ave., Montvale, NJ 07645	IEEE:	Institute of Electrical and Electronics Engineers 345 E. 47th St. New York, NY 10017
AGMA:	American Gear Manufacturers Association 1330 Mass Ave., N.W. Washington, D.C.	IES:	Institute of Environmental Sciences 940 E. Northwest Highway Mt. Prospect, IL 60056
AHS:	American Helicopter Society 1325 18 St. N.W. Washington, D.C. 20036	IFToMM:	International Federation for Theory of Machines and Mechanisms U.S. Council for TMM c/o Univ. Mass., Dept. ME Amherst, MA 01002
AIAA:	American Institute of Aeronautics and Astronautics, 1290 Sixth Ave. New York, NY 10019	INCE:	Institute of Noise Control Engineering P.O. Box 3206, Arlington Branch Poughkeepsie, NY 12603
AIChE:	American Institute of Chemical Engineers 345 E. 47th St. New York, NY 10017	ISA:	Instrument Society of America 400 Stanwix St. Pittsburgh, PA 15222
AREA:	American Railway Engineering Association 59 E. Van Buren St. Chicago, IL 60605	ONR:	Office of Naval Research Code 40084, Dept. Navy Arlington, VA 22217
ARPA:	Advanced Research Projects Agency	SAE:	Society of Automotive Engineers 400 Commonwealth Drive Warrendale, PA 15090
ASA:	Acoustical Society of America 336 E. 45th St. New York, NY 10017	SEE:	Society of Environmental Engineers 6 Conduit St. London W1R 9TG, UK
ASCE:	American Society of Civil Engineers 345 E. 45th St. New York, NY 10017	SESA:	Society for Experimental Stress Analysis 21 Bridge Sq. Westport, CT 06880
ASME:	American Society of Mechanical Engineers 345 E. 45th St. New York, NY 10017	SNAME:	Society of Naval Architects and Marine Engineers 74 Trinity Pt. New York, NY 10008
ASNT:	American Society for Nondestructive Testing 914 Chicago Ave. Evanston, IL 60202	SPE:	Society of Petroleum Engineers 6200 N. Central Expressway Dallas, TX 75206
ASQC:	American Society for Quality Control 161 W. Wisconsin Ave. Milwaukee, WI 53203	SVIC:	Shock and Vibration Information Center Naval Research Lab., Code 5804 Washington, D.C. 20375
ASTM:	American Society for Testing and Materials 1916 Race St. Philadelphia, PA 19103	URSI-USNC:	International Union of Radio Science - U.S. National Committee c/o MIT Lincoln Lab. Lexington, MA 02173
CCCAM:	Chairman, c/o Dept. ME, Univ. Toronto, Toronto 5, Ontario, Canada		
ICF:	International Congress on Fracture Tohoku Univ. Sendai, Japan		

## PUBLICATION POLICY

Unsolicited articles are accepted for publication in the Shock and Vibration Digest. Feature articles should be tutorials and/or reviews of areas of interest to shock and vibration engineers. Literature review articles should provide a subjective critique/summary of papers, patents, proceedings, and reports of a pertinent topic in the shock and vibration field. A literature review should stress important recent technology. Only pertinent literature should be cited. Illustrations are encouraged. Detailed mathematical derivations are discouraged; rather, simple formulas representing results should be used. When complex formulas cannot be avoided, a functional form should be used so that readers will understand the interaction between parameters and variables.

Manuscripts must be typed (double-spaced) and figures attached. It is strongly recommended that line figures be rendered in ink or heavy pencil and neatly labeled. Photographs must be unscreened glossy black and white prints. The format for references shown in DIGEST articles is to be followed.

Manuscripts must begin with a brief abstract, or summary. Only material referred to in the text should be included in the list of References at the end of the article. References should be cited in text by consecutive numbers in brackets, as in the example below.

Unfortunately, such information is often unreliable, particularly statistical data pertinent to a reliability assessment, as has been previously noted [1].

Critical and certain related excitations were first applied to the problem of assessing system reliability almost a decade ago [2]. Since then, the variations that have been developed and the practical applications that have been explored [3-7] indicate that ...

The format and style for the list of References at the end of the article are as follows:

- each citation number as it appears in text (not in alphabetical order)
- last name of author/editor followed by initials or first name
- titles of articles within quotations, titles of books underlined

- abbreviated title of journal in which article was published (see Periodicals Scanned list in January, June, and December issues)
- volume, number or issue, and pages for journals; publisher for books
- year of publication in parentheses

A sample reference list is given below.

1. Platzer, M.F., "Transonic Bluff Flutter - A Survey," *Shock Vib. Dig.*, 7, pp 97-106 (July 1975).
2. Bisplinghoff, R.L., Ashley, H., and Halfman, R.L., Aeroelasticity, Addison-Wesley (1955).
3. Jones, W.P., (Ed.), "Manual on Aeroelasticity," Part II, Aerodynamic Aspects, Advisory Group Aeronaut. Res. Devel. (1962).
4. Lin, C.C., Reissner, E., and Tsien, H., "On Two-Dimensional Nonsteady Motion of a Slender Body in a Compressible Fluid," *J. Math. Phys.*, 27 (3), pp 220-231 (1948).
5. Landahl, M., Unsteady Transonic Flow, Pergamon Press (1961).
6. Miles, J.W., "The Compressible Flow Past an Oscillating Airfoil in a Wind Tunnel," *J. Aeronaut. Sci.*, 23 (7), pp 671-678 (1956).
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